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ENGINEERING:

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See Full Page Advertisement March 8th.

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TENDERS.

IMPORTANT TO ENGINEERS.

By Order of The ENGINEERING IMPROVEMENT COMPANY, LTD., owing to Machinery having been requisitioned by the Government, and the Company's employees called up for active service.

Messrs. FULLER, HORSBY, SONS & CASSELL are instructed to invite

Tenders for the Purchase of

500 GROSS OF
"PERFLOC" PATENT LOCK NUTS,
namely:—300 gross of 1 in. and 500 gross of ⅞ in. made to Whitworth commercial standard gauge and finished bright. Samples may be seen at the Auctioneers' Offices, and Tenders may be for one, or any number of gross.

Tenders are also invited for the Purchase of the BENEFICIAL INTEREST IN AN AGREEMENT, dated 3rd July, 1917, with Vickers, Ltd., whereby for a period of five years they have the right of manufacturing "Perfloc" Lock Nuts on payment of Royalties. The purchaser would be entitled to these Royalties as and from the date of completion.

Tenders, which must be in the form contained in the Particulars of Sale, should be delivered not later than Twelve noon on MONDAY next, APRIL 15th, at the Offices of Messrs. FULLER, HORSBY & CO., Mechanical Auctioneers and Valuers, 133, High Holborn, W.C. 1. K 941

By Order of the Proprietor, who is retiring from business, Messrs. FULLER, HORSBY, SONS & CASSELL are instructed to invite

Tenders for the Purchase,

in one lot, as a GOING CONCERN, of the old-established
FREEHOLD SHIPBUILDING & ENGINEERING WORKS
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The works, which have the extensive frontage to Bow Creek of 480 ft., contain an area of nearly two acres. The buildings are conveniently arranged for economical construction and are equipped with modern Shipbuilding and Engineering Plant.

The whole of the fixed plant, machinery and fixtures, as also the
GOODWILL OF THE BUSINESS,
with patterns and drawings and work in progress, will be included in the sale. The purchaser will have an option of acquiring the loose plant, tools, stock and stores at a valuation. He will be entitled to the beneficial interest in the running contracts, but required to give an indemnity in respect thereof.

Tenders, which must be on the form attached to the particulars, must be delivered by Twelve noon on MONDAY, APRIL 22nd, at the Office of the AUCTIONEERS, 133, High Holborn, W.C. 1.

The Works may be viewed by orders only, to be obtained of Messrs. FORBES & SON, Solicitors, 19, Mark Lane, E.C., and of Messrs. FULLER, HORSBY & CO., Mechanical Auctioneers and Valuers, 133, High Holborn, W.C. 1. K 942

COUNTY BOROUGH OF SUNDERLAND.

The Corporation are prepared to receive

Tenders for the Supply and

ERECTION at their Electricity Works of one Forced Draught COOLING TOWER. The work to embody the use of such timber as can be worked in from two cooling towers at present occupying the site of the new one.

Specification and Form of Tender may be had upon application to the General Manager, Mr. ALFRED S. BLACKMAN, Electricity Offices, Dunning Street, Sunderland, upon payment of a deposit of £1, which will be returned only after a *bona fide* Tender has been opened.

Tenders endorsed "Cooling Tower," and addressed to the undersigned at the Town Hall, Sunderland, to be delivered not later than first post on Wednesday, 24th April instant.

The Corporation do not bind themselves to accept the lowest or any Tender.

H. CRAVEN,
Town Clerk.

Town Hall, Sunderland.
3rd April, 1918. K 991

Painting.—About 100,000

square yards of Painting REQUIRED to be done in a large Engineering Works in the Midlands, consisting of roof woodwork, steel principals, columns, crane tracks, &c. Firms DESIROUS of TENDERING for above should apply, in first place, giving approximate time for completion to K 992, Offices of ENGINEERING.

ALTERATION OF DATE.

Messrs. FULLER, HORSEY, SONS & CASSELL beg to announce that

Tenders for the Purchase of

the EQUIPPED ENGINEERING WORKS at Croydon will be received at their offices up to Twelve noon, on MONDAY, APRIL 22nd, instead of by the date previously advertised.

The tenants' fixtures, consisting mainly of
HIGH-CLASS MACHINE TOOLS,
are included in the sale, of which possession will be given on completion. The ground rent of the premises is £300 per annum and the unexpired term of 14 years, but the purchaser can determine the lease in 1921 or 1925, or should he desire permanent occupation, the freehold would be sold.

The purchaser will be at liberty, should he prefer to do so, to remove all, or any, of the machines to other works, after the 24th June next.

Further particulars may be had of Messrs. FULLER, HORSEY & CO., Mechanical Auctioneers and Valuers, 133, High Holborn, W.C. 1. L 29

TENDERS INVITED.

IN PRIZE.
BY ORDER OF THE MARSHAL OF THE ADMIRALTY,
MESSRS. KELLOCKS
are instructed to invite

Tenders for the Purchase of

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Triple Expansion ENGINES and Old FUNNEL ex s.s. "LUCIDA."

(Not accountable for errors in description.)

The above will be sold in the condition in which they lie at Middlesbro'.

The Admiralty Marshal does not bind himself to accept the highest or any tender, and tenders will be received by MESSRS. KELLOCKS until 10 a.m., WEDNESDAY, 17th APRIL, 1918.

For Orders to inspect, &c., apply to:—
C. W. KELLOCK & CO., L 58
Brokers to the Marshal of the Admiralty,
27-31, St. Mary Axe,
London, E.C. 3.

APPOINTMENTS OPEN.

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Wanted, as Soon as Possible,

INSTRUCTOR capable of lecturing on Elementary Electrical Engineering and giving practical instruction in the Laboratory and Wiring Workshop. Salary at least £4 per week. Full particulars as to duties and Forms of Application may be obtained from the undersigned.

A. C. BOYDE,
Secretary.

Education Office, Darlington.
April, 1918. L 21

BRISTOL EDUCATION COMMITTEE.

TEMPLE JUNIOR TECHNICAL SCHOOL (ENGINEERING).

Wanted, Immediately, for

the above-named School, a TEACHER of ENGINEERING SUBJECTS, including Metal-work and Machine Drawing. Preference given to a practical engineer with teaching experience. Candidates should be prepared to interest themselves in School Games and Physical Exercises with the boys.

Salary £180 per annum, rising by annual increments of £10 to £200 per annum.

Forms of application, which should be received not later than Thursday, 25th April, may be obtained by sending a stamped, addressed foolscap envelope to the undersigned.

WM. AVERY ADAMS,
Guildhall, Bristol. Secretary for Education.
9th April, 1918. L 27

Clerk Wanted by Large Firm

of Electrical Engineers in London. Must be accustomed to dealing with correspondence. Only discharged soldiers or men exempt from service need apply. No one already on Government work or residing more than 10 miles away need apply.—Write, stating age, experience, and salary required, to BOX 441, WILSONS, 135, Fleet Street, E.C.4. L 5

Wanted, Steel Works Chemist

for steel foundry with electric furnace. No one at present on Government work will be engaged.—Apply at your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4973. L 17

Wanted, Metallurgical

CHEMISTS, to take charge of shift on 7-ton Electric (Héroult) Furnace; must have first-class experience with Carbon and Alloy Steels, also laboratory practice. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4948. K 856

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First-class man to take charge of Iron and Bronze Foundries, must have thorough practical and technical knowledge of all branches of Foundry work. Must also have first-class experience of latest machine moulding methods. Present output 70/75 tons per week.—Apply, stating age, experience and salary required, to ALFRED HERBERT, LTD., Machine Tool Makers, Edgwick Works, Coventry. K 965

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Fittings REQUIRED for Government Controlled Aircraft Factory in Eastern Counties.—Apply, stating age, experience and salary required, to nearest EMPLOYMENT EXCHANGE, mentioning this paper and K 992. No one already on Government work can be engaged.

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AIRCRAFT WORKS, LONDON.

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Applications are Invited for

the POST of HEAD of PURCHASING DEPARTMENT in a large Aeroplane Manufacturing Firm.

Applicants must have had wide commercial experience in the purchase of engineer's materials and tools, and in sub-contract work.

Full details must be sent of experience and previous positions held. Age and salary required must be stated. All such details will be treated in strict confidence.

No one will be engaged who is on Government work or resident more than 10 miles away.

Address, K 967, Offices of ENGINEERING.

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Works Engineer Wanted for

Operating and Maintaining Plant in large mill. Experience with boilers, high and low speed engines, hydraulic and general machinery necessary. Must be good disciplinarian.—Address, L 24, Offices of ENGINEERING.

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Wanted, Two Skilled Setters-

UP for Machine Shop. Must be able to set up Centre Lathes, Capstan Lathes, Drilling and Milling Machines. None but the most experienced men need apply. No one already engaged on Government work need apply.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 26.

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NEERS WANTED for large Power Station, to take charge of Steam Raising Plant and Running Staff (not repairs). Experience of water-tube boilers, supervision of firemen, and practical boilerhouse tests essential. Applications will be treated in confidence, and should give full particulars of actual experience in direct charge of boilerhouse plant. £5 per week, including War Bonus to date.—Apply, K 926, Offices of ENGINEERING.

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Temporary Assistant

ENGINEERS REQUIRED for the completion of the Contract Surveys and Plans for the construction of a large Storage Reservoir, etc., in connection with the water supply to City of Belfast.

Applicants must have thorough experience of the design and construction of Storage Reservoirs, etc., and be neat and accurate draughtsmen. Applications, stating age, qualifications and experience, also salary expected, accompanied by copies of not more than three recent testimonials, to be sent to Mr. F.W. McCULLOUGH, M.Inst.C.E., Chief Waterworks Engineer, Belfast. K 971

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INTENDENT REQUIRED for three years' service on the Federated Malay States Railways, with possible extension. Should have a general knowledge of stores and store-keeping (railway stock keeping preferred) including buying, examination, storing, accounting and auditing, and be capable of taking charge of the stores department when required. Age not to exceed 35 years, preferably unmarried; loss of an eye or the left arm not a disqualification. Salary £380-£15-£500 with a duty allowance of £80 a year. Free passages. Apply at once, by letter, giving full particulars to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W. 1, quoting M/8332. No person engaged on Government work or eligible for the army need apply. L 41

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for night work in Blue Print Room of Government Department, London. Previous experience not necessary. No person resident more than 10 miles away or already engaged on Government work will be engaged. Applications to be made in writing only, stating age and salary required to OFFERS OF SERVICE SECTION, Room 354, MINISTRY OF MUNITIONS, Whitehall Place, S.W. 1. L 43

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Required, by Firm Manu-

facturing Aero Engines in the neighbourhood of Bristol, Two ESTIMATORS (one machining and one fitting). Only first-class men, not already engaged on Government work, need apply to nearest EMPLOYMENT EXCHANGE, mentioning this paper and L 28, stating age, experience, salary required and position as regards the Military Service Act.

Tool Makers, Fitters, In-

SPECTORS REQUIRED for Government Controlled Establishment in Eastern Counties. Good wages paid.—Apply, stating age, experience, to nearest EMPLOYMENT EXCHANGE, mentioning this paper and K 903. No one already on Government work can be engaged.

Wanted, a Rate Fixer in the

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Wanted, in Government

Office, London, Civil Engineering ASSISTANT, experienced in Ferro Concrete Jetty Work. Also Civil Engineering ASSISTANTS for General work. Applicants must be ineligible for General Military Service, and should give full particulars of their experience, qualifications and age, with references or copy of testimonials, and state salary required, BOX 1235, WILLINGS, 125, Strand, W.C. 2. K 984

Wanted at Once, by Large

Government Controlled Establishment, a DRAUGHTSMAN, capable of making neat sketches from actual machines. Discharged Soldier preferred. Only those not already on Government work and residing within a 10 mile radius need apply.—Address, stating age and experience, to L 48, Offices of ENGINEERING.

Draughtsmen.—Highly

experienced Mechanical Draughtsmen WANTED immediately for Drawing Office of Government Department, London. No person resident more than 10 miles away or already engaged on Government work will be engaged.—Applications, with full particulars of previous experience, to be made to OFFERS OF SERVICE SECTION, Room 354, MINISTRY OF MUNITIONS, Whitehall Place, S.W. 1. L 42

Wanted, Civil Engineering

DRAUGHTSMAN in a Government Office at Devonport, fully competent to Design Steel Buildings and Structures, and have a knowledge of ferro-concrete work. Ineligible for General Military Service and not already in Government employment.—Write, stating age, salary required, full particulars of experience, &c., and enclosing recent testimonials, to BOX 1251, WILLINGS, 125, Strand, W.C. 2. L 6

Draughtsman (Jig and Tool)

WANTED for large Aeroplane works in Lancashire district, knowledge of press work, tools for automatics (Cleveland and Acmes, Capstans) and all woodworking machines. No person already on Government work will be engaged. Only experienced men need apply, stating age, full experience, and salary required, at your nearest EMPLOYMENT EXCHANGE, quoting No. A 5013. L 9

Draughtsmen, Two Required,

experienced in Reinforced Concrete Design. No one residing more than 10 miles away or employed on Government work will be engaged.—Address, L 18, Offices of ENGINEERING.

Draughtsman Wanted for

London engineering works, some knowledge of chemical plant preferred. No one engaged on Government work, or residing more than 10 miles away need apply.—Write, stating age, experience and salary required, to L 37, Offices of ENGINEERING.

Engineer - Draughtsman, to

assist Works Manager of Controlled Firm, North-East District. An excellent opening with good post-war prospects for a live man, not afraid of work; able to prepare working drawings quickly from rough sketches and supervise the work in the shops. Applicant must be a good all round man not under 24 years of age.—Address, stating age, full details of experience and salary required, K 919, Offices of ENGINEERING.

Draughtsman Required to

TAKE CHARGE of Coal Washery Department. Experienced men only need apply.—Full particulars in the first place to K 894, Offices of ENGINEERING.

Wanted, by a Large London

Aircraft Engineering Works, a number of good Mechanical DRAUGHTSMEN, men with previous aeronautical experience preferred. Write, stating age, experience and salary required. No one will be engaged who resides more than 10 miles away or who is on Government work. — Write, BOX 263, SELLS, Ltd., 168, Fleet St., E.C. 4. K 892

Good Mechanical Draughts-

MEN WANTED by large controlled firm in Manchester district. Must be quick and accurate at detail work. No person already on Government work will be engaged. Apply, with full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4731. K 944

WHIRLING AND WHIP OF A REVOLVING SHAFT.

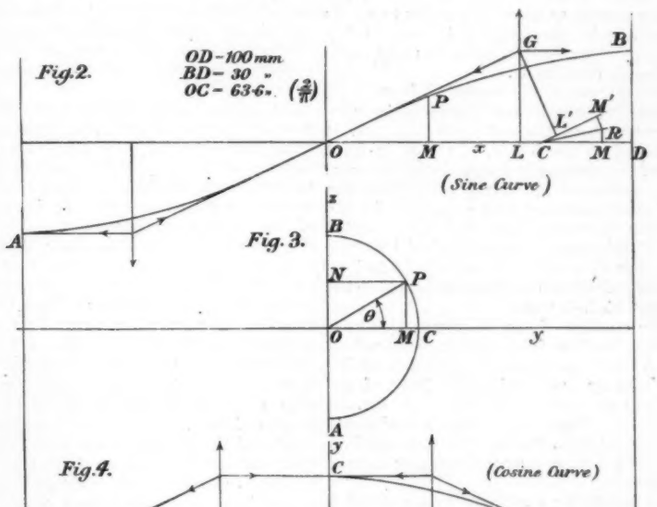
By G. GREENHILL.

(*Continued from page* 274.)

9. NEXT to investigate the effect of centrifugal force (C.F.) due to whirling, the shaft making N revolutions / second, an angular velocity (A.V.) $\omega = \frac{N}{2\pi}$, radians/second, consider a half wave of the helix in Fig. 2, 3, 4, and calculate the resultant C.F. acting on it.

Write $\omega^2 l = g$, so that l is the height of the conical pendulum making the same revolutions. With our units l must be measured in inches, thus for a cycle period of 2 seconds, $l = 39.1383$ inches, say 40 inches in round numbers, the length in the Act of Parliament of the simple pendulum that beats the second; this makes $l = 10$ inches for a period of 1 second, and $l = \frac{10}{N^2}$ inches, for N revolutions/second.

The projection of the half-wave on its medial cross section, seen in the semicircle A C B in Fig. 3



is equivalent to a semicircular wire of linear density $\frac{m}{\sin a}$, lb/inch, m denoting the linear density of the wire or shaft, $m = w\,\mathrm{K}$, where w denotes the density of the metal, in lb/inch^3.

The C.F. on A C B is the resultant of a distributed radial force

$$\frac{m}{\sin a}\,\frac{b\,\omega^2}{g} = \frac{m}{\sin a}\,\frac{b}{l} = \frac{m\,a}{l}\ \text{lb/inch}, \qquad . \quad (1)$$

acting as if it was a uniform internal pressure; and the resultant over the arc A C B is equal to the resultant across the chord or diameter A O B, and is therefore

$$\frac{m\,a}{l}.\,2\,b = 2\,m\,\frac{a^2}{l}\sin a,\ \text{lb} \qquad . \quad . \quad (2)$$

In the half-wave of the helix, shown in Fig. 2 projected on the plane $x\,O\,z$ in the half-wave of the sine-curve A O B, the component C.F. at P parallel to O z will be proportional to P M, and in the quarter wave O B the resultant C.F. in this direction will act through the C.G. of the area O B D, and this is proved (in §16) to be at a distance from O z, parallel to O x, equal to p the theoretical pitch, and on the line through the intersection of the tangents at O and B.

The resultant C.F. on the quarter wave O B parallel to O z is half the C.F. on the half wave A C B parallel to O y; and with the equal and opposite C.F. on the quarter wave A O, it makes up a couple of moment p times the C.F. on A C B.

On the cosine curve A C B in the projection of the half wave on the plane $x\,O\,y$ in Fig. 4, the C.F. on each quarter wave parallel to O y is in the same direction, and equivalent to the C.F. on the half-wave A C B in Fig. 3.

We conclude then that the C.F. of force and couple on the half-wave A C B of the helix make up a wrench about the axis O C y, of pitch p.

Equating the component couples acting at the ends A and B, as before (in §8), about axes parallel to O C, to the moment of the C.F.,

$$2\,\mathrm{A}\left(\frac{\sin^2 a}{b} - \mathrm{L}\sin a - \mathrm{X}\,b\cos a\right)\cos a = 2\,m\,\frac{a^2 p}{l}\sin a. \qquad . \quad . \quad . \quad (3)$$

$$\mathrm{A}\,\frac{\sin^2 a}{b} - \mathrm{L}\sin a - \mathrm{X}\,b\cos a = \frac{m}{\sin^2 a}\,\frac{b^5}{l} \qquad . \quad (4)$$

$$\frac{\mathrm{A}}{a^4} - \frac{\mathrm{L}}{a^3} - \frac{\mathrm{X}}{a^2}\cos a - \frac{m}{\mathrm{L}} = 0 \qquad . \quad . \quad (5)$$

$$\mathrm{A}n^4\cos^4 a - \mathrm{L}\,n^3\cos^3 a - \mathrm{X}\,n^2\cos^3 a - \frac{m}{l} = 0 \qquad . \quad (6)$$

In the helical wire or the equivalent shaft, sprung slightly, so that cos a may be replaced by unity,

$$\mathrm{A}n^4 - \mathrm{L}\,n^3 - \mathrm{X}\,n^2 - \frac{m}{l} = 0 \qquad . \quad . \quad (7)$$

This is the relation obtained in the Transactions of the Institution of Mechanical Engineers, 1883, page 206, when, with the notation changed from L, T, P, to A, L, X, the two differential equations (9) and (10) there on putting $y + i\,z = w$, are combined into the single equation,

$$\mathrm{A}\,\frac{d^4 w}{d\,x^4} - i\,\mathrm{L}\,\frac{d^3 w}{d\,x^3} + \mathrm{X}\,\frac{d^2 w}{d\,x^2} - m\,\frac{w}{l} = 0 \qquad . \quad (8)$$

a differential equation of the fourth order with constant coefficients; and assuming a solution $w = e^{i\,n\,x}$, the quartic equation for n is obtained, as before in (7).

10. Consider, for instance, a flexible rope or chain, whirled round in a uniform helix; here A = 0, L = 0, and if T denotes the tension, and h the tension length, T = $m\,h$, X = − T cos a,

$$\mathrm{T}\,n^2\cos^2 a = \frac{m}{l},\ \mathrm{L}\,h\,n^2\cos^2 a = 1,\ l\,h = p^2\sec^2 a = a^2 = \mathrm{O\,G}^2,$$

if a denotes the length of rope for a radian angle, 57.3 deg., turn of the helix. The same relation would be obtained by equating the component tension, T sin a perpendicular to the axis of the helix, at the ends of the half wave, to the C.F.

$$2\,\mathrm{T}\sin a = 2\,\frac{m}{\sin a}\,\frac{b^2}{l} = 2\,m\,\frac{a^2}{l}\sin a,\ l\,h = a^2 = \mathrm{OG}^2 \qquad . \quad (1)$$

in Fig. 1 (see page 273 *ante*), where l, h may be shown geometrically.

While the rope makes one turn in time $\mathrm{T} = \frac{2\pi}{\omega}$, the helix appears to advance an axial distance the wave-length $\lambda = 2\pi p$; so that the wave velocity

$$\mathrm{V} = \frac{\lambda}{\mathrm{T}} = p\,\omega = \sqrt{\frac{g\,p^2}{l}} = \cos a\,\sqrt{(g\,h)} \qquad . \quad . \quad (2)$$

reducing to $\sqrt{(g\,h)}$ for a taut rope, $a = 0$, the usual expression, with tension-length h.

But if a is very nearly a right angle, the wave velocity appears very small. Thus the general expression for the velocity of helical waves along a slack rope is given in (2), and has been obtained from elementary considerations.

The helix may appear stationary in form, as a screw advancing and turning through a fixed nut; and then the particles of the helical rope advance tangentially instead of revolving in a circular orbit. This can be seen in the jet from the nozzle of a fire-engine hose, or in the life-line thrown over a wreck from a mortar.

The dynamical conditions are unaltered, and if v is the tangential velocity

$$v = \mathrm{V}\sec a = \sqrt{(g\,h)},\ \mathrm{T} = w\,h = w\,\frac{v^2}{g} \qquad . \quad . \quad (3)$$

in accordance with a general law for the free motion of a chain along a curve fixed in space, the form appearing unaltered, as in a jet.

Starting out then with the revolving flexible rope, and through the elastic shaft, and so on to the Kelvin gyrostatic chain, an elementary treatment can be applied to all these problems, on the assumption of the form of the uniform helix.

11. Under the operation of the wrench transmitted, the shaft is twisted as well as bent, and denoting by C, lb-inch^2, the torsional rigidity, it is such that the twist of τ radians in a length of λ inches, or a twist $\mathrm{R} = \tau/\lambda$, radians/inch, requires a twisting couple C R = L', suppose.

Then in the shaft

$$\mathrm{L} = \mathrm{L}'\cos a + \mathrm{A}\,\frac{\sin^2 a}{b}\sin a = \mathrm{L}'\cos a + \mathrm{A}\,n\sin^2 a\cos a \quad (1)$$

and substituting in (6) §9,

$$\mathrm{A}\,n^4\cos^6 a + \mathrm{L}'\,n^3\cos^4 a - \mathrm{X}n^2\cos^3 a - \frac{m}{l} = 0 \qquad . \quad (2)$$

$$\mathrm{A}n^4\cos^4 a + \mathrm{L}'\,n^3\cos^2 a - \mathrm{X}n^2\cos a - \frac{m}{l\cos^2 a} = 0 \qquad . \quad (3)$$

The effect of the twist of the shaft would be shown in Fig. 1 by the displacement of a helical line engraved on the surface of the shaft into a new helix, such that the straight line O G, development of the helix when the surface is rolled out flat, is displaced slightly into another straight line O G'.

Thus with no rotation:

$$\mathrm{A}n^2\cos a - \mathrm{L}\,n - \mathrm{X} = 0 \qquad . \quad . \quad . \quad (4)$$

$$\mathrm{A}n^2\cos^3 a + \mathrm{L}'n\cos a - \mathrm{X} = 0 \qquad . \quad . \quad . \quad (5)$$

and replacing n by $\frac{1}{p} = \frac{1}{a\cos a}$,

$$\mathrm{A} - a\,\mathrm{L} - a^2\,\mathrm{X}\cos a = 0 \qquad . \quad . \quad . \quad (6)$$

$$\mathrm{A}\cos a + a\,\mathrm{L}' - a^2\,\mathrm{X} = 0 \qquad . \quad . \quad . \quad (7)$$

Interpreted geometrically on Fig. 2, with O G = a, O L = p, L = X δ, L' = X δ', A = k^2 X, L C = δ,

$$k^2 = a\,(a\cos a + \delta),\ \mathrm{O\,C} = \frac{k^2}{a},\ \mathrm{OC{\cdot}OG} = k^2 \qquad . \quad (8)$$

$$k^2\cos a = a\,(a - \delta'),\ \delta' = a - \mathrm{O\,C}\cos a, \qquad . \quad (9)$$

so that $\delta' = \mathrm{C\,L}'$, if G L' is the perpendicular from G on the line through C parallel to O G.

12. Kirchhoff's "Kinetic Analogue" may be stated here in its generality, as showing how the same analysis and geometry can be applied to two distinct mechanical questions, and thereby afford mutual support.

The "Analogue" states that if an elastic round wire or rod is bent and twisted into its most general tortuous curve under the action of an equal opposing wrench at each end with vertical axis, the shape of the curve is such that if a point moves along the curve with constant velocity, the hodograph of its motion is a spherical curve which can be identified as the curve described by a point in the axle of a symmetrical top spinning about a fixed point, and in the same period by a proper choice of the constant velocity.

And the projection of the tortuous curve of the wire on a horizontal plane may be taken as the curve traced out by the vector of angular momentum of the top.

The analogy is worked out completely in my

"Report on Gyroscopic Theory," 1914, page 76. The uniform helix we have considered here is the analogue of a top in steady motion, with the axle at a constant angle a with the vertical; and the velocity of the point along the helix is such as to make a circuit in the same period as the top.

With O L vertical in Fig 2, and C the fixed point in the axle C L′ of the top, then C L and C L′ will represent the constant angular momentum component about the vertical and the axle, and C G the resultant angular momentum.

And if C R is drawn at right angles to C G, and R M, R M′ are perpendiculars on L C, C L′, chosen so that C M′ is the S.E.P. length of the top, swinging without rotation as a plane pendulum, then C M will be the height of the conical pendulum which rotates round the vertical C M at the same rate as the top in steady motion.

13. In the ordinary nut on a screw bolt, or in the close helical spring (Halsey), commonly but improperly miscalled spiral, the angle a is very nearly a right angle, and the pitch is small; so that it is usual to measure it in the inverse way by the number, $\frac{n}{2\pi}$, of threads or convolutions to the inch.

Then, in the equation (7) §11,

$$a^2 X = A \cos a + a L' \quad . \quad . \quad . \quad (1)$$

the term A cos a can be neglected as insensible, and

$$X = \frac{L'}{a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

so that the resilience of such a spring is due chiefly to torsion, and very little to the bending, as pointed out by James Thomson (Thomson and Tait, 1867, §608).

14. In the general biquadratic (7) §9 the presence of Ln^3, due to the couple transmitted, makes it insoluble in the algebraical sense.

But with L = 0, and the shaft under a thrust X only, the biquadratic reduces to

$$A n^4 - X n^2 - \frac{m}{I} = 0,$$

a quadratic in n^2, with two real roots for n^2, but one of them negative; this means that the corresponding cos $n x$ and sin $n x$ must be replaced by the hyperbolic functions ch $n x$ and sh $n x$.

With no rotation, $\omega = 0$, $l = \infty$, $A n^2 = X$, leading to the ordinary Euler formula for the flexure of a strut or column under the thrust X, and then

$$\frac{2\pi}{\lambda} = n = \sqrt{\frac{X}{A}},$$

and λ is the length of a wave.

If the ends of the shaft are allowed play in direction only, or if the bearings preserve the axial direction but are allowed side play,

$$\frac{\pi}{\frac{1}{2}\lambda} = \sqrt{\frac{X}{A}}, \quad \frac{1}{2}\lambda = \pi\sqrt{\frac{A}{X}}, \quad . \quad (3)$$

with $\frac{1}{2}\lambda$ the distance between the bearings.

If the bearings are absolutely fixed in position and direction, *encastré* is St. Venant's word, λ is to be taken as the distance between bearings,

$$\lambda = 2\pi\sqrt{\frac{A}{X}} \quad . \quad . \quad . \quad (4)$$

Expressed in terms of e, Young's elastic length, $E = m e = w K e$, and with h the head of the thrust, $X = w K h$,

$$\left.\begin{aligned} \lambda &= 2\pi\sqrt{\frac{E K k^2}{X}} = 2\pi k\sqrt{\frac{e}{h}} \\ &= 2\pi\sqrt{\frac{e k^2}{h}} = 20{,}000\,\frac{\pi k}{\sqrt{h}} \text{ inches.} \end{aligned}\right\} \quad . \quad (5)$$

with $e = 100$ million inches; and for a hollow round shaft $k^2 = \frac{1}{8}$ (sum of square of external and internal diameters).

In this way we investigate the origin of the side way buckling in driving a pile or a long nail, or even leaning on a wooden yard measure.

(To be continued.)

THE SCIOTOVILLE BRIDGE.

By FRANK W. SKINNER, M.Am.Soc.C.E.

(Continued from page 194.)

WE give, on the opposite page, in Fig. 16, a diagrammatic view of the Sciotoville Bridge, on which are marked the reference letters relating to the chief members of the structure, while Fig. 17 on the same page shows the half of the bridge adjoining the Ohio shore drawn to a larger scale and giving further reference markings. On both these diagrams are shown the falsework piers, with which we dealt in the earlier part of this article. These diagrammatic views will be found useful to refer to in connection with our further descriptions of the methods of erection of the bridge.

We also give this week, on Plate XXXVII, in Figs. 18 to 23, detail views of the gantry traveller which formed such an important part of the erecting plant. As explained on page 194 *ante*, this traveller was at first not erected to its full height, the transverse girders being fixed at a point about 90 ft. below that at which they were ultimately placed. On Plate XXXVII, in Fig. 18, the transverse girders are shown in their lower, and in Fig. 19 in their final, position, while Figs. 20 to 23 show details in connection with the erection of the structure.

Jacking the Ohio Span—The falsework for the Ohio span was commenced in May, 1916, and completed in September. The erection of the 13,500,000-lb. steel span, 775 ft. long, was completed about the end of January, 1917. Special effort was made to advance the erection of the Ohio span as rapidly as possible in order to enable the falsework to be removed and the span safely supported on the permanent piers, so as to avoid imminent danger from floods.

After the Ohio span had been erected from L–20, at the centre pier, to L–12, the removal of the falsework was commenced at the centre pier, and the Ohio span was jacked up about $\frac{3}{8}$ in. at the L–12 point by the use of two 200-ton hydraulic jacks that also reduced the reaction at L–16, Ohio span. When the erection of the trusses had been completed for the Ohio span the Kentucky span had been erected to L–17. At this time the Ohio end of the Ohio span, L–0, was 8 in. too low and was jacked up $\frac{3}{8}$ in. by a force of 660,000 lb. per truss to relieve the falsework bent at L–4, Ohio.

During the erection of the Ohio span the lower chord bearing on the falsework at intermediate panel points, where the pressure was much smaller was maintained by means of wedge jacks of 200 tons capacity, such as are shown at L–6, in Fig. 24, Plate XXXVIII. These were very powerful and were operated by 2-in. runner lines attached to long handle wrenches, engaging the square ends of the wedge screws.

When the Kentucky cantilever was completed to panel-point 10, the Ohio end was jacked to final elevation and the rockers inserted. This operation also raised the trusses off the steel falsework columns and the entire structure became self-supporting. The reactions being about 1,150 tons, the trusses were lifted by a group of one 500-ton and four 200-ton jacks per truss, seated on steel grillages, distributing their loads on the end pier of the bridge. The jacks took bearings against heavy castings set under the end floor beams, as shown in Fig. 25, Plate XXXVIII. Fig. 26, on the same Plate, shows segmental expansion rollers used as shims under the pedestal at L–0 end of Ohio span when lifted.

The rocker bearings for the trusses at L–0 consisted of shoes and pedestals having hole bearings for transverse pins. The pedestals are seated on four 16-in. segmental rollers, on cast bases bolted to the pier masonry. When erection was commenced the segmental rollers were omitted, and when the trusses were jacked to position the pins and fastenings were supported from above by special bolts. While jacking at L–0, shim plates were inserted between the pedestal and the bolster to follow up every movement of the jacks. After the trusses had been lifted a few inches the shim plates were replaced by segmental rollers 4½ in. thick, laid flat, and acting like solid slabs reaching within a short distance of the base of the pedestal where the remaining space was filled with thin shim plates until the required height was reached. The two middle rockers were put in place, then the shim plates and slabs were removed, and the two outside rockers were inserted in their proper position and connected to their side frames.

Erection of Kentucky Span.—The first two panels or 75 ft. at the north end of the Kentucky span, adjacent to the centre pier, were erected on falsework by the steel gantry traveller that, after completing them, continued on the Ohio span falsework with the erection of the Ohio span as already described. While this erection was proceeding two panels, or 77½ ft. farther, on the Ohio side of the centre pier, a steel creeper traveller was erected on the top chord of the Kentucky span trusses and was completed and ready for service when the gantry traveller had completed the Ohio span trusses to a total length of 150 ft. beyond the centre pier. Of the constructive details of this creeper traveller we shall have more to say later on, but meanwhile we may mention that it will be seen in position in Fig. 27, Plate XXXVIII, and Fig. 30, Plate XXXIX.

The creeper traveller erected one panel only of the Kentucky span before the completion of the erection of the Ohio span. After the Ohio span was completed the creeper proceeded with the cantilever erection of the Kentucky span.

The erection stresses of the overhanging Kentucky span, acting as a cantilever, were greater in some members of the truss than their maximum working stresses in the finished span. In order to reduce them and avoid the necessity of unduly large cross-sections for the members, steel falsework bents were provided at the third and fourth main panel points of the bottom chord, namely, at the panel points L–8 and L–4, 465 ft. and 620 ft. respectively from the centre pier.

As fast as the trusses were completed to these points they were landed on the falsework bents, as as shown in Fig. 27, Plate XXXVIII, jacked up to the required height, and thus transformed the completed portion of the truss from a cantilever to a continuous truss structure; the further extensions of the trusses produced new cantilevers. Thus the span was erected as three short cantilevers instead of one long one, the short cantilevers successively terminating and commencing at each intervening support, instead of one long cantilever reaching from pier to pier. This reduced the maximum cantilever length from 775 ft. to 465 ft., and greatly increased the stability of the work.

The type and design of the trusses were such that they could be erected in complete short panel lengths of 38 ft. 9 in., thus reducing the length and weight of the separate truss members, simplifying their connections at panel point, and enabling the traveller to easily handle them and maintain them in position until connections were made. This reduced the dimensions and weight of the traveller, made a proportionate reduction in the moment developed by it, and thus effected a saving of steel or temporary reinforcement that would otherwise have been necessary in the trusses. This feature, together with the reduction in the length of the cantilever arms were very important considerations for the safety, economy and rapidity of the erection.

It may be convenient here to say a few words concerning some illustration given in the present issue of portions of the bridge, to which special reference has not yet been made. Thus Fig. 28, on Plate XXXIX, shows the floor beams and stringers on the wooden falsework with portions of the lower chord in place ready to receive the uprights. It may be noted that pin-connected shoes and pedestals (such as are illustrated in Fig. 9, on page 82 *ante*, already referred to) alternate with wedge intermediate supports to carry the sections of the lower chord. This view, Fig. 28, is of interest as giving a very clear idea of the arrangement of the rails on which the travelling gantry ran. Fig. 29, on the same Plate XXXIX, gives details of the bottom chord panel L–16, and shows the supports of the truss on the pin-connected shoes and pedestal seated on the steel falsework column.

Fig. 30, Plate XXXIX, is of interest as showing a stage in the erection of the Kentucky span in which the trusses cantilevered to nearly the maximum amount. At this date all the wooden falsework had been removed from the Ohio span. The gantry traveller had also been removed, but the stiff-leg derrick was still installed on the top chord near the Ohio shore. Fig. 31 on the same Plate shows the top chord panel points U–14, and gives a good idea of the arrangement of the lateral bracing of the bridge.

THE SCIOTOVILLE BRIDGE; DETAILS OF TRAVELLING GANTRY.

(For Description, see Page 388.)

Fig. 18. SECTION F.F. Fig. 21.

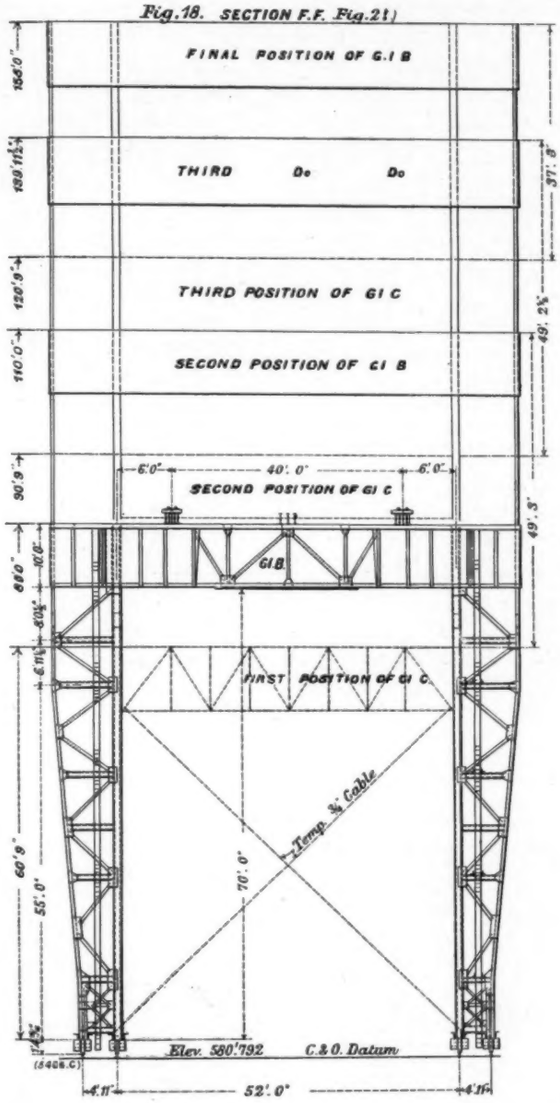
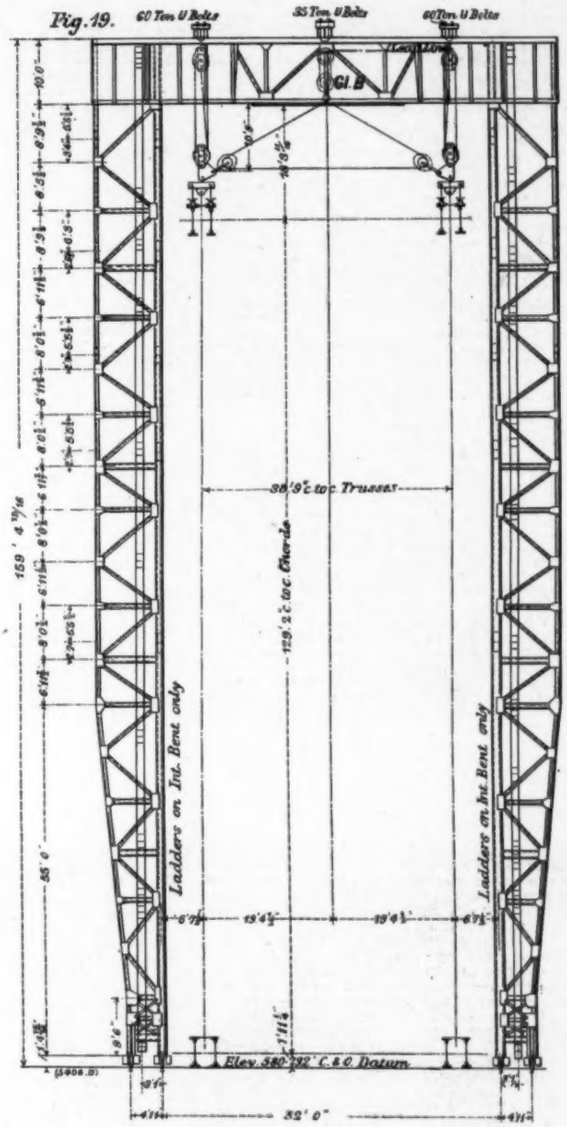


Fig. 19.



HALF PLAN SHOWING POSITION OF MAST FOR ERECTING CENTRE GIRDER & OTHER HALF OF GANTRY.

Fig. 20.

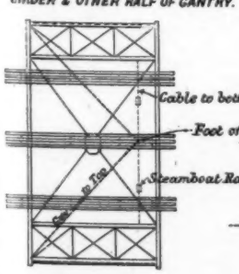


Fig. 21.

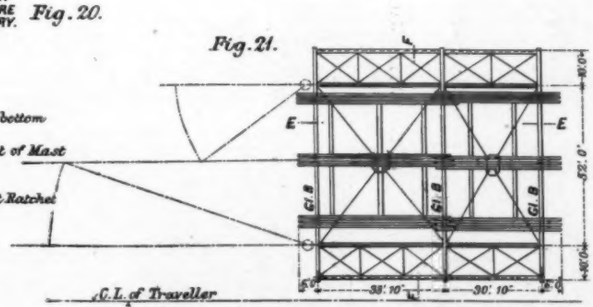
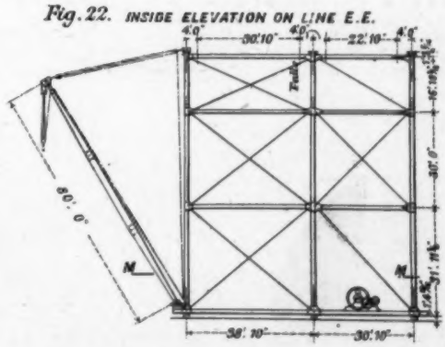


Fig. 22. INSIDE ELEVATION ON LINE E.E.



HALF PLAN N.N. SHOWING SWINGING TACKLE

Fig. 23.

(To face page 388.)

THE SCIOTOVILLE BRIDGE OVER THE OHIO RIVER.

MR. GUSTAV LINDENTHAL, NEW YORK, ENGINEER.

(*For Description, see Page* 388.)

FIG. 24. WEDGE JACKS, 200 TONS CAPACITY.

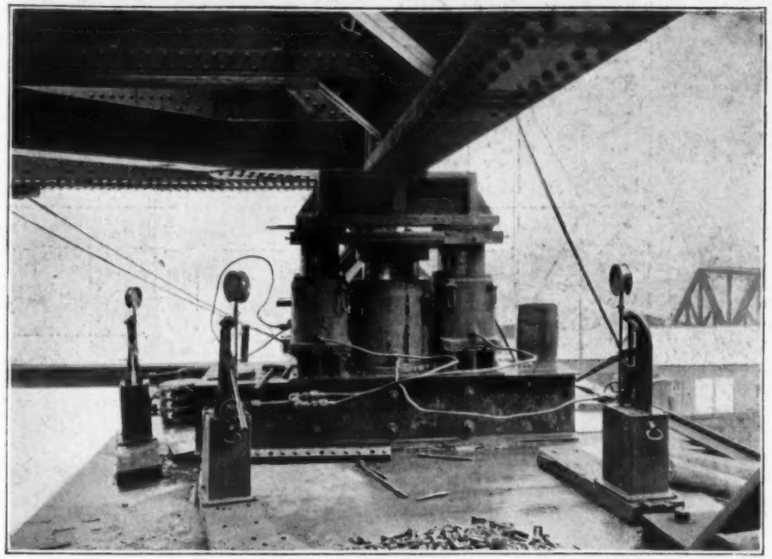


FIG. 25. GROUP OF 500-TON AND 200-TON HYDRAULIC ADJUSTING JACKS.

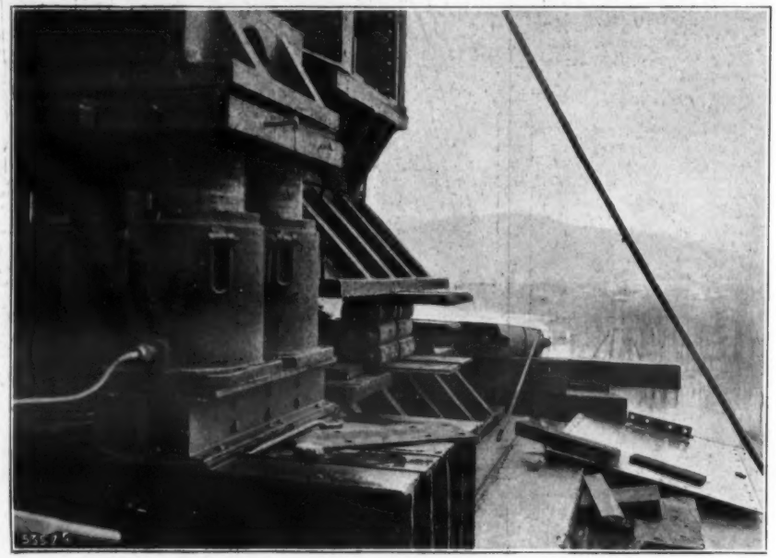


FIG. 26. THE L-0 END OF THE OHIO SPAN PACKED UP AFTER LIFTING.

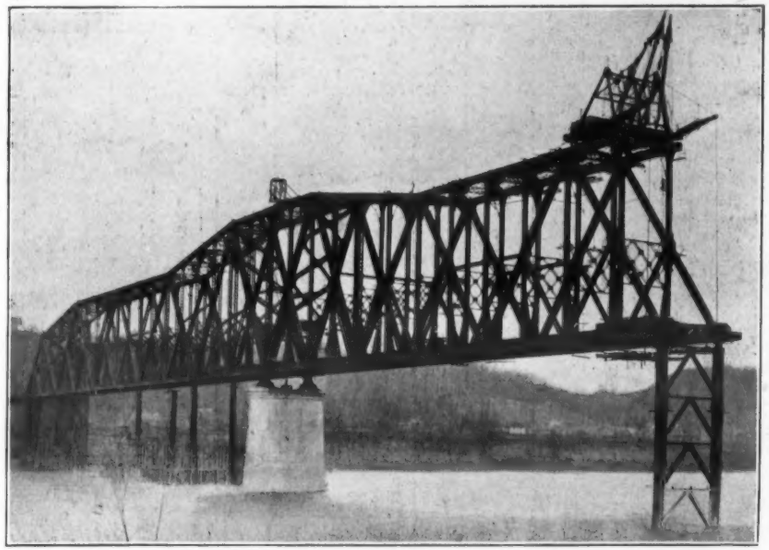


FIG. 27. VIEW OF PARTIALLY-ERECTED BRIDGE LOOKING TOWARDS THE KENTUCKY SHORE.

THE SCIOTOVILLE BRIDGE OVER THE OHIO RIVER.

MR. GUSTAV LINDENTHAL, NEW YORK, ENGINEER.

(*For Description, see Page* 388.)

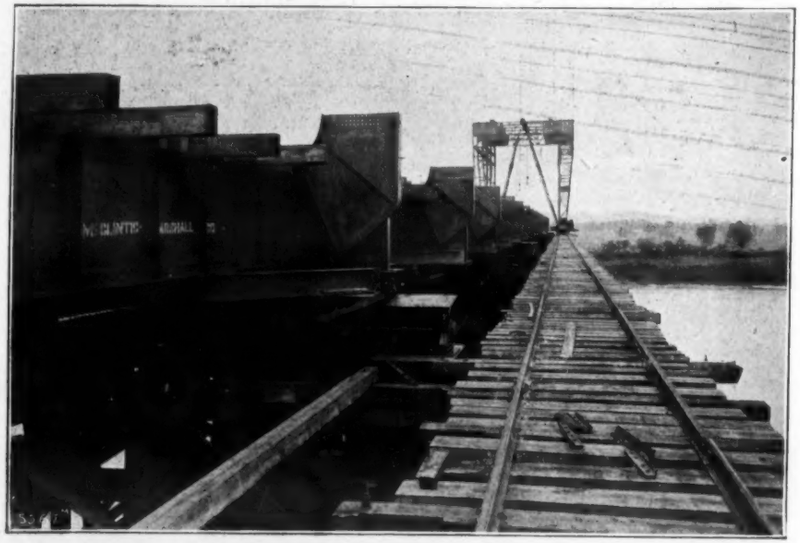


FIG. 28. FLOOR BEAMS AND STRINGERS ON FALSE WORK WITH PORTIONS OF LOWER CHORD IN PLACE.

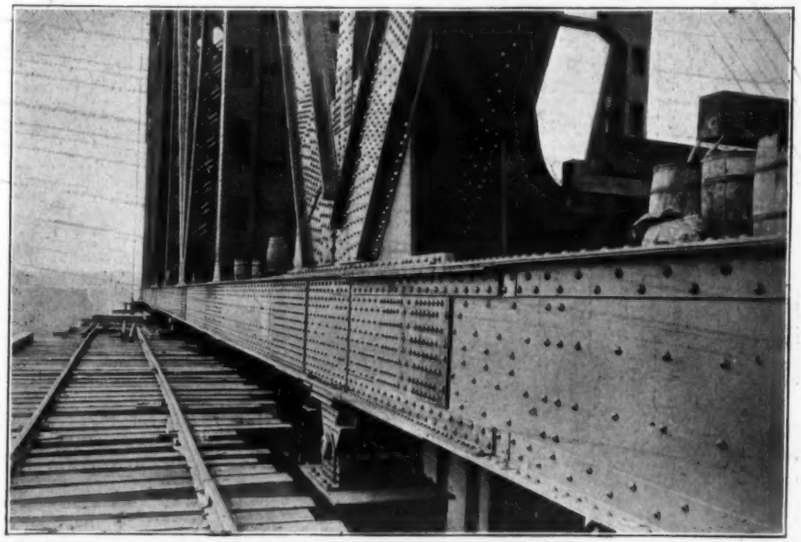


FIG. 29. BOTTOM CHORD PANEL L–16.

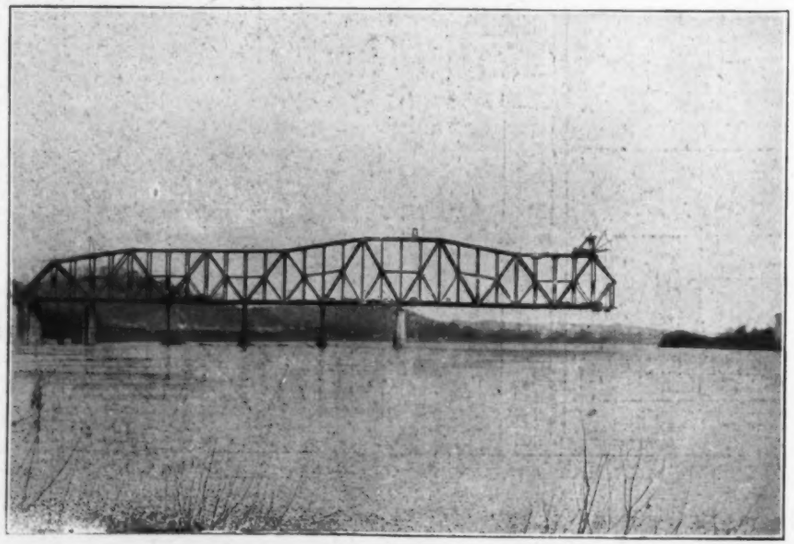


FIG. 30. THE KENTUCKY SPAN DURING ERECTION.

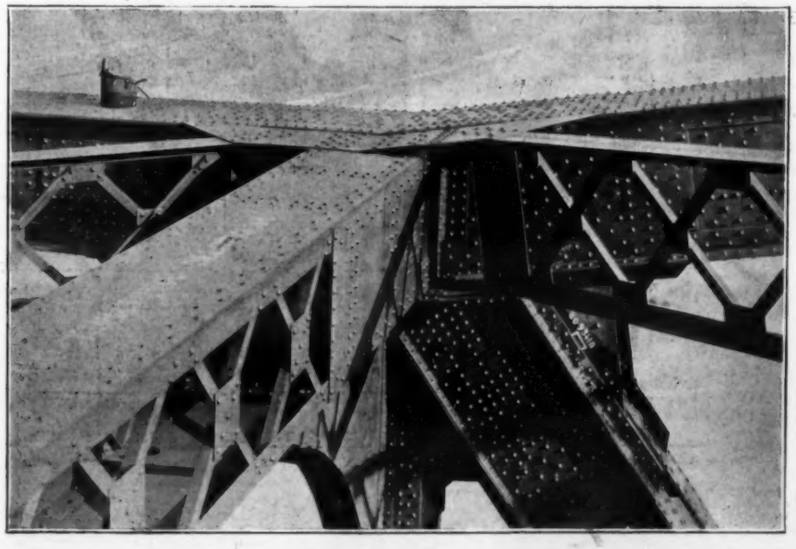


FIG. 31. TOP CHORD PANEL POINTS AT U–14.

THE SCIOTOVILLE BRIDGE OVER THE OHIO RIVER.

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(*For Description, see Page* 388.)

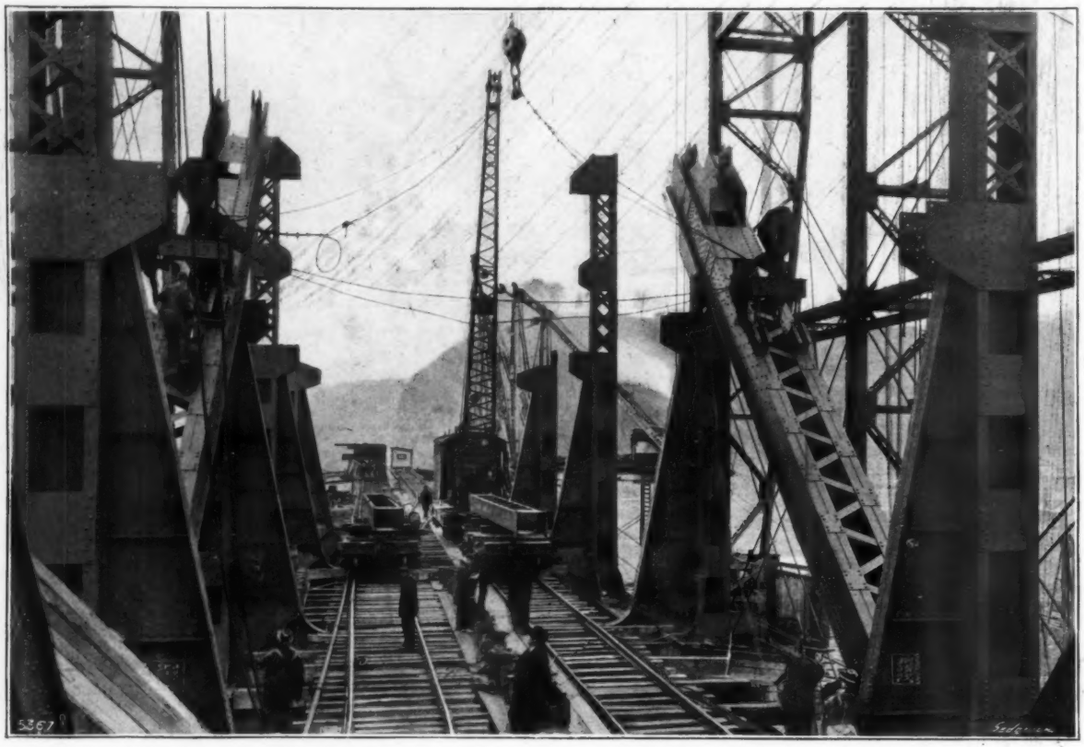


Fig. 32. Lifting the Two Inclined Web Members L-4, M-3.

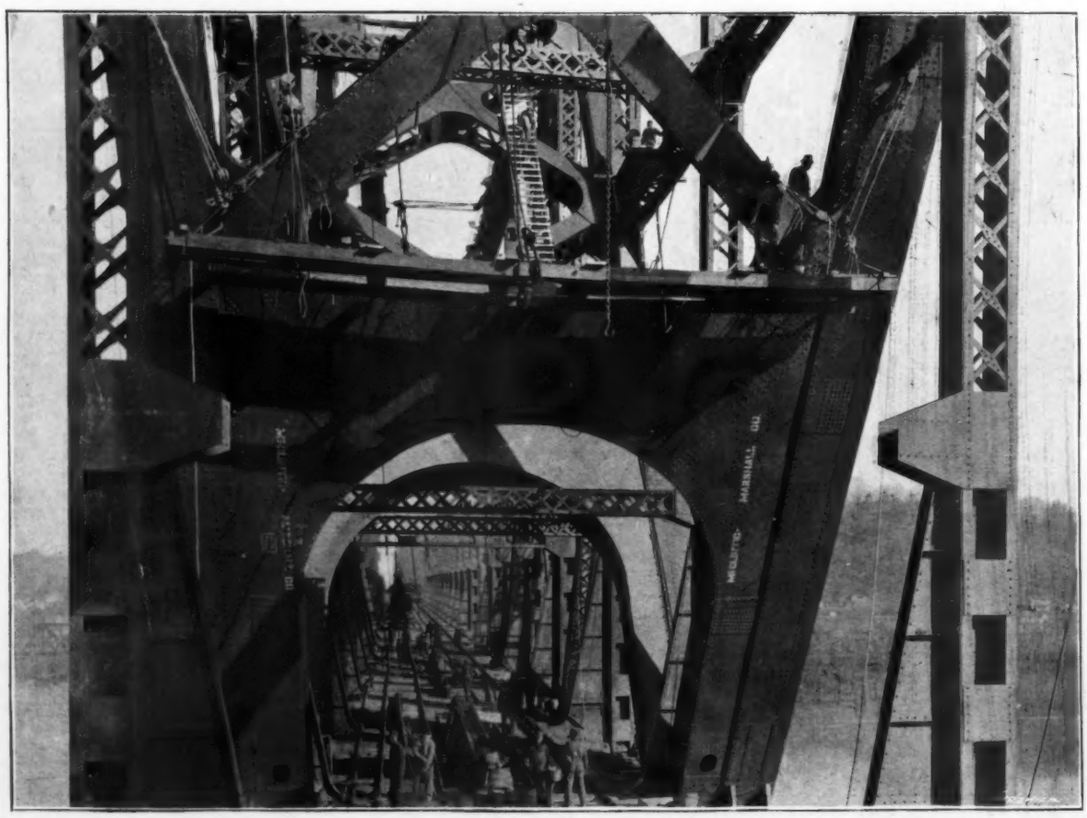


Fig. 33. One of the Main Inclined Portals and Double Bracing at Points 18.

(*To face page* 389.)

THE SCIOTOVILLE BRIDGE OVER THE OHIO RIVER.

MR. GUSTAV LINDENTHAL, NEW YORK, ENGINEER.

Fig. 16.

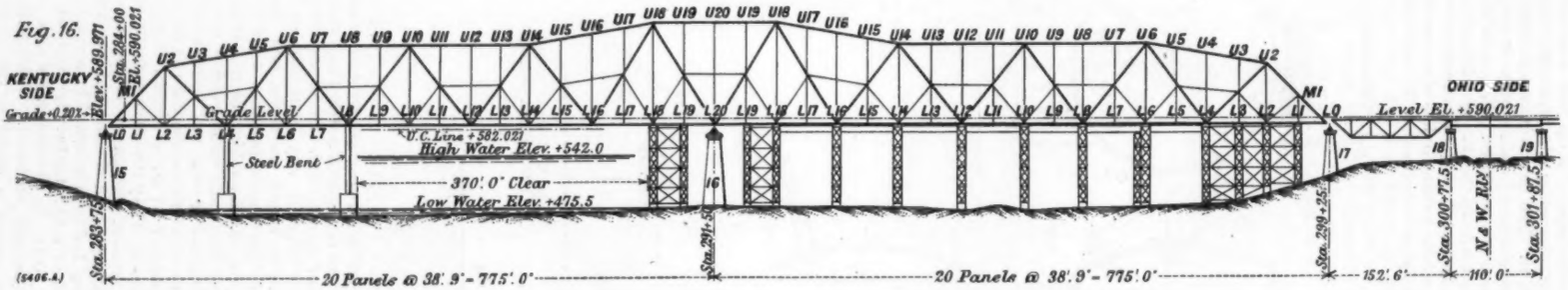


Fig. 17.

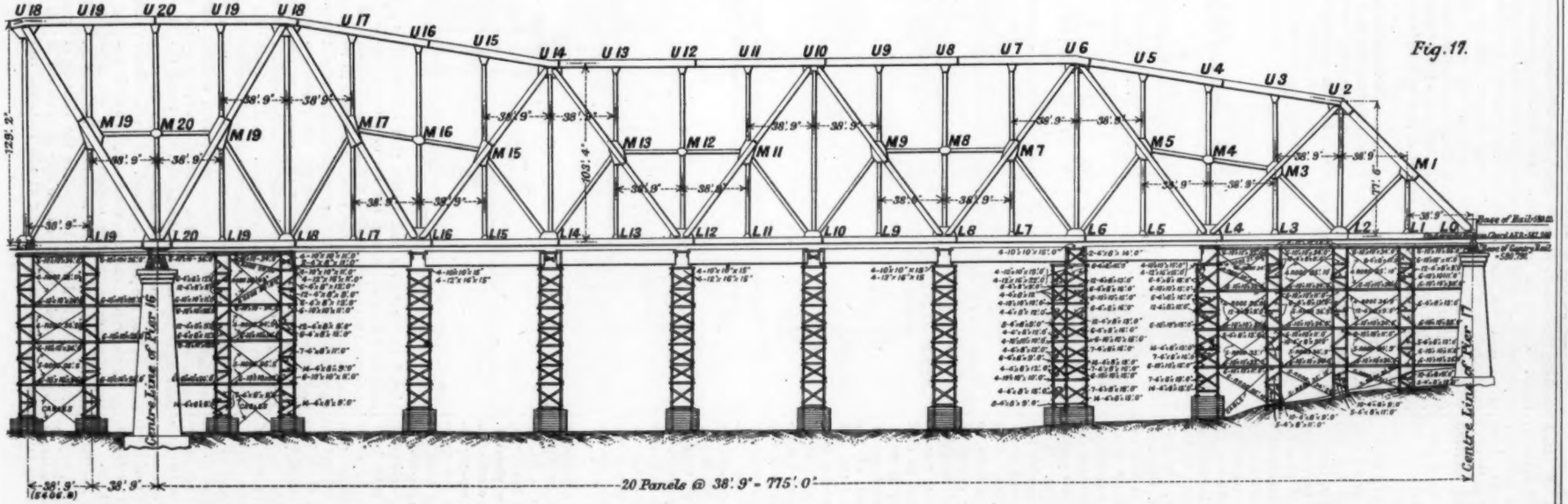


Plate XL contains two very interesting views. Of these Fig. 32 shows the simultaneous hoisting of the two inclined web members L–4, M–3, of the Ohio span, the travelling gantry tackle being attached to lifting pieces temporarily bolted to the members. The other view, Fig. 33, is one taken at a much later stage of the work, and shows one of the main inclined porta's and double bracing at panel points 18.

Adjustment of Cantilever Bearings.—After the Kentucky span had been erected to L–9, a total cantilever length of 426 ft. 3 in., the erection of the temporary steel falsework bent at L–8, shown in Fig. 27, already referred to, was proceeded with.

The erection of this bent was done at a time when the concrete piers provided to support it were 15 ft. under water. The possibility of this condition having been anticipated, the anchor bolts to secure the pedestals of the columns had been extended about 22 ft. upward by single-length sleeves of 2-in. pipe which projected above the surface of the water and served as guides engaging the open holes in the bottoms of the pedestals. On them the pedestals slipped down to accurate position on the tops of the piers to which they were bolted by a diver after the pipe sleeves were removed.

The falsework bents were removed from under the Ohio span trusses and were provided with horizontal braces connected to kneebraces bearing on the lower chord at panel point L–9, that provided stability for the falsework bent until after the creeper traveller had erected the lower chord panel L–9, L–8 which was bolted to it. The falsework bent acted as a rocker bent, as it did under the Ohio span.

After the completion of panel L–8, L–9, the trusses were jacked up with a force of 412,000 lb. each, adjusted to bearing on the falsework bent, and the erection continued as a new cantilever arm to L–4, where a second temporary falsework bent was built and supported the trusses as at L–8. At this time the reaction at point L–8 had increased to 2,000,000 lb., and the trusses were jacked up at L–4 with a force of about 470,000 lb. per truss, after which the erection was continued in the same manner to the completion of the span at L–0. The reactions at L–4 and at L–8 were computed at 2,000,000 lb. and of 1,195,000 lb. respectively. These reactions corresponded to a deflection of 16¼ in. below normal at L–0, which was then jacked up with a force of 2,337,000 lb. where it received its permanent bearing. This jacking relieved bents L–4 and L–8, which were afterwards removed.

In order to accomplish the connection of the truss members that were fabricated with lengths providing for cambre, it was necessary to distort the truss at times. For the bottom chords this was done by means of Norton jacks under the chord reacting against the girders of a flying bridge under the bridge floor that was hung by eyebars from lateral outriggers on the traveller. The vertical posts and some of the diagonals and top chords were forced to connection position by means of hydraulic jacks and yokes, as previously described.

The erection involved the driving of about 360,000 field rivets, 1¼ in., 1 in. and ⅞ in. in diameter, which were driven by about 15 gangs operating pneumatic hammers. The average erection force was about 175 men. The total time of erection of falsework and superstructure was about fourteen months.

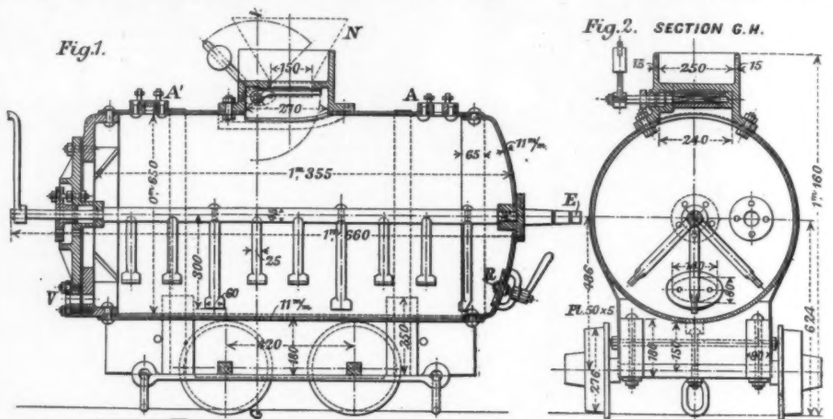
(To be continued.)

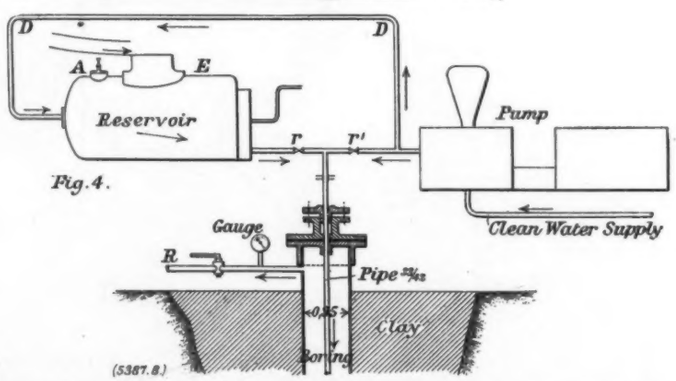
MUD INJECTION IN COAL MINES.

A SHORT time since attention was directed in these columns to the good effects that followed the deposition of a mud lining in oil wells, both as providing a cheap and rapid means for preventing the inflow of water into the wells, and also for checking the tendency of the oil to disseminate itself through the sands and become commercially useless. M. Plassard now urges a somewhat similar plan for extinguishing fires in collieries, for the recovery of coal under unfavourable working conditions, and for ensuring greater safety to the workpeople. At some mines in France, the plan has been occasionally used, but now M. Plassard, possibly influenced by his transatlantic experience, and certainly encouraged by his success at Saint Eloy, has urged its systematic and wider adoption, giving precise practical details to facilitate its effective working.* The author sees further opportunities for the extension of the scheme. With slight necessary modifications, he recommends the method as suitable for securing greater safety for coal cargoes at sea. He points out, that of 77 steamers chartered to distant ports, seven failed to reach their destination owing to the effects of spontaneous combustion. Of five ships freighted to San Francisco, two were burnt. Good reasons are given for believing, that if a process of mud discharge throughout the cargo had been in operation, these losses would have been reduced, and if not perfectly successful, the provision of the necessary apparatus would have reduced the risk and been of use in fighting the danger arising from overheating. Perhaps, too, it may be pointed out in this connection, that the Liverpool Underwriters' Association has recently made a strong appeal for the provision of more effective appliances for detecting and extinguishing fires on board ships. This urgent need is shared by shippers, shipowners, consignees and underwriters alike. From experience that the world has acquired of German methods, the Liverpool Society has no hesitation in attributing many of these casualties to deliberate action on the part of the enemy. The danger is, however, sufficiently imminent at all times, war tactics or war outrages only increase a very obvious risk.

Originally M. Plassard adopted the plan described by M. Clavelly, and one that had been in use at the Aubin mines. In the main, it consists in forcing from a tank or reservoir a mixture of incoherent rubbish and water under considerable pressure. This ejected material can be forced into crevices or made to form a protective coating to embankments. The method by which brick linings in a few mines have been strengthened by injections of sand and cement has much in common with that proposed by M. Plassard, but he aims at a more general adoption by utilising the worthless refuse of the mine itself. M. Clavelly apparently used cinders from the furnaces; but this material was soon exhausted at Saint Eloy, and recourse was had to the refuse from coal washings mixed with 50 per cent. of cinders. With such a mixture, however, it was found that, the finer material was heavier than the cinders, and that the velocity of the water at command, about 1 m. a second, did not prevent the "mud" from sinking, and that only about one-half of the whole contents of the apparatus were ejected. To prevent the heavier material from sinking to the bottom of the tank a greater velocity in the propelling water was necessary. As an alternative, compressed air was applied and proved so effective, that the whole contents of the reservoir could be ejected as by the piston of a force pump. The object of the author is to exhibit the method of working the scheme so as to obtain the full advantages, to show the convenience and economy of a compressed air apparatus, and at the same time to prove that the use of combustible materials to extinguish fires is unattended with danger. The very successful results obtained at Saint Eloy are fully demonstrated, and not a little of the importance of the paper consists in the care with which the details and precautions are explained and insisted upon.

The form the apparatus finally assumed is shown in Figs. 1 to 3. In its main features it consists of an iron reservoir or tank, of 450 litres capacity, weighing 750 kg. with mounting complete. In this are





placed the materials and water, that on forcible ejection are to extinguish the fire or provide protection. On the lower side is a waste pipe V which can be connected with the mine or borehole to be operated upon, and on the upper side an inlet pipe A communicates with a compressed air apparatus. A second pipe A^1 accelerates the working of the process by providing an escape for the compressed air on the completion of an operation. This is exceedingly simple, and the apparatus can be easily worked by two men. It consists in mixing the solids and water, approximately in equal proportions, well together by means of paddles or stirrers worked by hand from the outside. Practically, it is found undesirable to introduce the water through the same aperture as the solid material. A tube, shown at E, connected with the water supply, avoids this inconvenience, since the cinders, &c., are most suitably shovelled into the removable funnel at N. The opening and cover R facilitate the cleaning of the apparatus; but if a little care is exercised in the selection and screening of the material, this operation need give little trouble. Large pieces of brick and heavy slag have to be avoided as these may stop delivery. Cinders that will pass through a riddle having round holes 20 mm. in diameter prove to be of a suitable size.

Since the capacity of the tank is not large, quickness in completing the cycle of operations is important. Two men require 4 minutes to insert the materials and 2 minutes more to stir the whole to a homogeneous mass. With a sufficient water supply, it is found that the operation can be finished in 7 minutes, but practically this degree of rapidity is not attained, owing to loss of time in the arrival of the skips and other causes. In fact, four complete operations in an hour are considered satisfactory, and at this rate approximately 1 cub. m. of material per hour is deposited. Under all circumstances, progress depends very materially on the time required to empty the tanks, and this depends again on the effective pressure of the water or air employed. At Saint Eloy, as mentioned, the loss of water head from various causes was such that the available pressure was insufficient to prevent the heavier materials settling. An air pressure giving a velocity of 17 m. a second, however, proved sufficient to empty the whole contents of the tank in 30 seconds, through an orifice of 8.5 sq. cm. If a sufficient head of water had been available, or the force had been increased by a pump, the compressed air would still have had economical advantages. With the air current, the ratio of solid to liquid remains unaltered. With water, the incoming current is added to the initial mixture, gradually reducing its density, so that the operation has to be stopped when the solid contents fall below the required amount. Thus, complete evacuation

* "L'Embouage aux houillères de Saint Eloy," par M. A. Plassard. Bulletin et *Comptes Rendus Mensuels de la Société de l'Industrie Minérale.* 2e livraison de 1917.

is never effected, and the tank is not utilised to its full capacity. It may, however, be desirable to use either air or water, according to conditions, and a change from one to the other can easily be effected. A detailed examination of the working of the process by air and by water shows that with compressed air the work can be carried on three times as rapidly as with water, while the water consumption is reduced to one-sixth. These results speak for themselves.

M. Plassard raises the question whether danger is to be apprehended from permitting any of the compressed air to have access to the fire to be extinguished. Considering the small quantity of air that from faulty operation or other causes might come in contact with active fire, he decides that the risk is negligible. There are three possibilities to be considered. In the first, which includes the great majority of cases, the cinder and mud distribution is a purely preventive measure scattering the tank contents over a cold or slightly-heated region. In this condition the entrance of air can have no ill effects. In the second case, the space to be protected may be large, containing combustible gas with detached fires. Such conditions might occur in old galleries abandoned without sufficient gob support. Here air admitted might lead to the formation of explosive mixtures, and care is needed under such circumstances. Lastly, it is possible that a fire is clearly declared, and then the air introduced would tend to increased activity, but this would be diminished as the quantity of solid material accumulated. At Saint Eloy, where the apparatus has been used without the protective discharge pipe at A^1, no injurious effects have been experienced.

It is more pertinent to inquire, whether the use of partially-combustible materials is unattended with danger, and here again the answer is reassuring. In the first place, the greater part of these cinders and coal washings never come near a fire. The known difficulty of burning such refuse even on a boiler grate tends to prove that similar waste, containing perhaps 50 per cent. of cinders, deposited hydraulically on a fire with light draught, would only tend to extinguish it, and this the more quickly as the accumulation of waste was more rapid. If a smouldering fire should rekindle, undoubtedly the cinders and other combustible matters more or less dried, would burn, but the total mass under this superficial covering would be less inflammable than at first, and would yield readily to a fresh treatment. Spontaneous combustion of the refuse is certainly not to be feared, even in the huge accumulations resulting from the collection of such materials in the abandoned workings already mentioned. Such a mixture as that contemplated and deposited in the way described would form a mass so compact that no air could circulate in it. Overheating would not supervene, even if some fissures were produced by sinking.

The nature of the material employed that would be best calculated to have the desired effect is to be decided by the conditions prevailing. If large spaces are to be filled, or covered, under the conditions existing in the second class of cases referred to, any material can be used as sand, ordinary sifted cinders, or fine slate. Employed in this way, the machine might be regarded as a hydraulic puddler (*remblayeuse hydraulique*). Again, the object of the deposition may be to fill up many narrow voids occurring in partially-worked seams, or to strengthen a crushed pillar, or fill a subsidence. It is desirable in such circumstances to use very fine siftings, so as to fill all the crevices as thoroughly as possible. Siftings from the furnaces, or coal washings, are suitable in such cases. Where crumbling masses have to be protected, or very fine fissures in hard rocks have to be filled, clay in a colloidal condition may be used with advantage. The time element has also to be considered. Where it is necessary to give some measure of support to weak places as quickly as possible, it is better to use materials that settle rapidly. Fine clays in suspense are then not suitable.

In the foregoing, M. Plassard's methods have assumed that the distribution of the tank's contents will be effected by an ejecting force, either air or water. But it is also possible to secure the same object, only less perfectly, by simply pouring the material on to the fire, if by boring or other means the seat of the trouble can be reached. The radius of protective action will be diminished, because such an operation is purely superficial, and the mixture is not forced into the neighbouring fissures. Therefore, under these simple circumstances, it is still desirable to employ a pump or suitable appliances to maintain the necessary pressure. In such cases, clay and slow-settling solids will be found advantageous lest the borehole, of small diameter, should be prematurely blocked. When a fire is situated at a depth not exceeding 15 m., hand boring can be adopted and access usually secured without difficulty. A boring-bit of about 50 mm. is recommended, but with so small an opening the use of only a very thin mixture is possible, if blocking the passage is to be avoided, a danger that evidently increases with the length of the hole and the friable character of the rock perforated.

Far more difficult operations, carried through with success, demonstrate the practical character of the scheme. An old gallery, 210 m. long, that had been abandoned for a year owing to the repeated occurrence of severe fires, had to be repaired and made safe in order that a seam of coal beneath might be worked. The abandoned cutting was at a depth of about 40 m. and had to be reached by borings, through very difficult ground, owing to broken coal, heavy timber left from previous work, and large stones in the gob stuff. Four perforations had to be made and the bore was large, 0.35 m. diameter, and the machinery heavy, in order to break through all obstacles encountered, while

Fig. 5. SECTION ON X.Y.

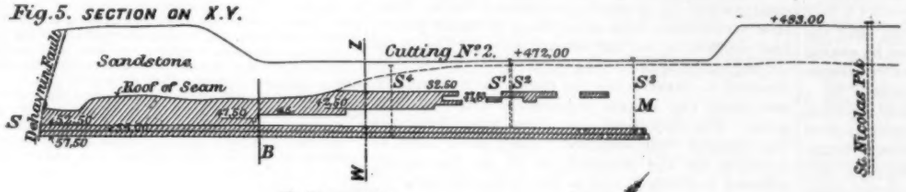


Fig. 6. SECTION ON W.Z.

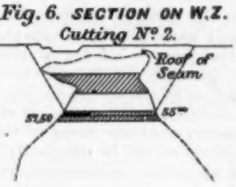


Fig. 7.

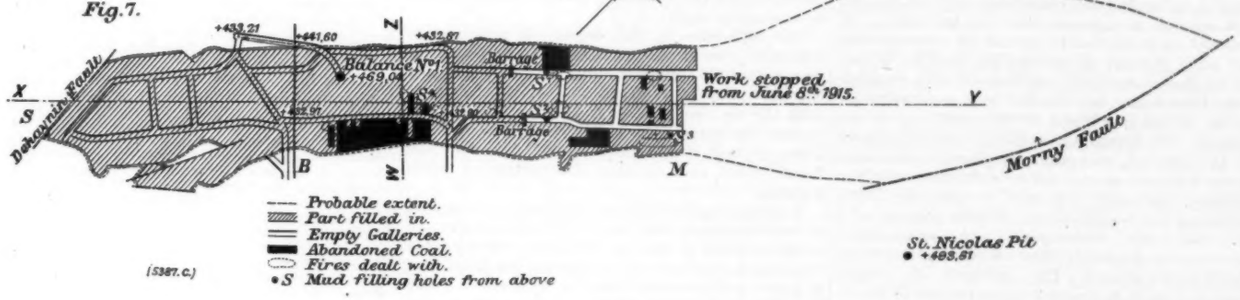
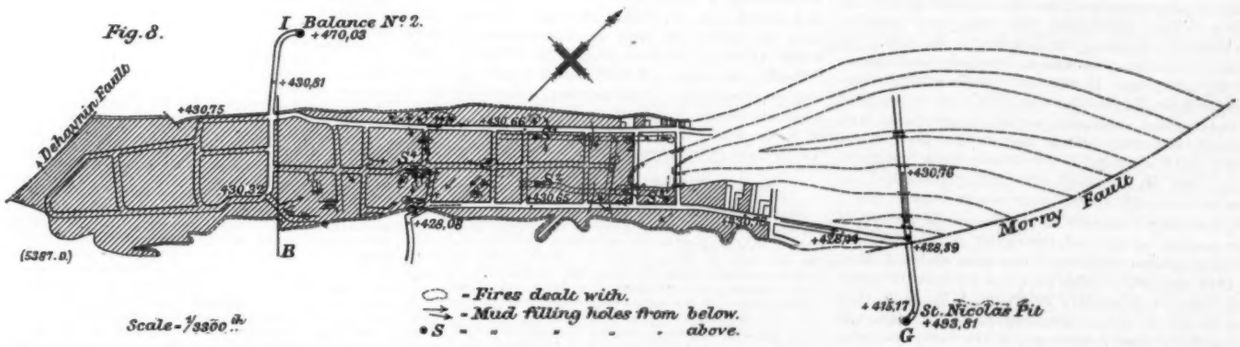


Fig. 8.



special precautions had to be taken to prevent the hole being blocked by crumbling rock. On reaching the cutting to be treated, it was found that mud protection could be given both with and without pressure. For the operations without pressure, sufficient clay and material was at hand, but mixed with foreign matter of a bulky nature that proved inconvenient. By a simple device, the rougher ingredients were easily removed. The whole mass was thrown into a trough on which a stream of water could play, and on being stirred, the heavier and coarser portion sank to the bottom, while the excess water carrying clay in a fine state of division was allowed to overflow, and could be led to the boring. About six-tenths of a cubic metre of dry material passed in an hour. The consumption of water varied, but the volume was about four to six times as great.

In this kind of operation it is evident that the muddy water penetrates into the crevices by reason of the pressure of the column of water above. This pressure can be conveniently increased by a pump, or by the special appliances already detailed. In order that the operation should succeed, it is necessary that the rocks in the immediate neighbourhood should be comparatively watertight, and that no unlined subterranean passages should allow the water to escape. In the four borings just mentioned and described as made through broken ground, naturally these conditions were not fulfilled and special precautions had to be taken. M. Plassard's scheme had to submit to a severe test, but came through it successfully, and he is convinced that under good conditions a very complete protection would be afforded over a considerable radius of action. When it was necessary to use pressure, the apparatus, working with compressed air as explained, was originally placed at the head of the boring, but this led to difficulties with the drainage, not easily overcome, because the boring apparatus had been removed to make progress with the other holes. Subsequently, the arrangement made was analogous to that adopted in cementing waterlogged ground. The injection of muddy water was made by a central pipe as shown in Fig. 4. This arrangement permits the circulation of clear water while preventing the deposited material prematurely blocking the bottom of the hole. On several occasions the side of the hole broke away during pumping. It was not possible to tube the hole, because the crevices would not then be reached. It is true that successive sections might have been treated, and then tubed, but if this plan would avoid earth slipping, it introduces fresh complications, and M. Plassard does not recommend its adoption except under extreme conditions.

Convincing evidence of the beneficial effects of the general method of treatment is provided by comparing the condition of the mine at Saint Eloy in 1915 and 1917. This previous work in the mine had been so frequently interrupted by fires, that two-thirds of the recoverable coal had been left untouched. Every attempt to win more coal was defeated by outbursts of fire, but by great exertion the work on the level 55 m. was extended 220 m. north of B, Figs. 5 and 7. In no less than 12 places, fires had been encountered and fought, but despite all efforts, very considerable masses of coal were still in the mine. Finally, in June, 1915, the fires became fiercer than ever, and the smoke compelled a retreat, a length of 210 m. being abandoned in an unsafe condition, and insufficiently isolated from the remainder of the workings. Fig. 7 shows the condition at that level. The hatchings indicate the waste, and the solid black, the coal untouched. The white lines mark the position of the drifts, and the dotted ellipses the fire centres.

The programme for future operations that was resolved upon had for its aim (1) the entire exhaustion of the coal at the level 57.50 m. to the north of B, Fig. 5, immediately below the abandoned workings; (2) to extend operations 200 m. more to the north on the same level—a region that had previously been injured by fire but which had not been within the sphere of recent operations. Thanks to the efficient protection afforded by mud and clay covering, the first part of this programme was fully realised in May, 1917, and very considerable progress made in the second. Confining attention entirely to the work of mud distribution, this important salvage extending over 12,000 sq. m., was effected by making 74 injections, which absorbed 1,520 cub. m. of dry material. In 15 of these, the object was preventive, but in 59 direct attack was made on 18 fires encountered in the work of exploitation. The radius of action was in general 8 m. to 10 m., but in some cases it was necessary to get to closer quarters. Fig. 8, showing the state of operations in May, 1917, on the level 57.50 m., is comparable with Fig. 7. The position of the fires is here indicated by small ellipses and the points of mud injection by arrows. It will be seen that these fires occur in groups, making some spots particularly dangerous, calling for energetic measures, and the machinery being local in its action is particularly adapted to deal with such emergencies. A general protection of the whole area would have been superfluous at many points, and ineffective in the worst places. The work accomplished at the boring S. 4, Fig. 7, was entirely directed to overcoming the fires, which it will be seen from Fig. 8 were particularly active at that point. The object of the three other boreholes was equally well achieved. They were used as channels for the material to fill up the empty galleries mentioned, and in strengthening and consolidating the banking. The empty spaces were filled to a distance of about 30 m. from each borehole, and the remaining portions easily yielded to subsequent work.

The difference in the degree of consolidation attained by the mixture of cinders and coal washings was noticeably different from that of the clay deposits. The latter when shut off from contact with the air hardened very slowly, and when wet tended to reduce the solidity of the banking. Three or four months after deposit the clay was found moist and clammy, provocative of earth slipping.

Experience gained at Saint Eloy with this method of working shows that mud injections used in the neighbourhood of fires are efficacious, offering great relief to the workmen by permitting the circulation of more air than would otherwise be prudent. Also by allowing a closer approach to the seat of fire, the attack can be better directed. Further, the plan can safely be used as a temporary remedy where thorough repairs would be attended with difficulty, or danger, if undertaken before ameliorating conditions have been assured. Some ingenious applications are indicated by M. Plassard. Details of these would vary according to conditions and the method of mine working.

Primus Stoves.—The Primus stove is ordinarily started by a flame of methylated spirit which heats the burner until it gasifies the paraffin forced into it by the air pressure in the container. Methylated spirit is, however, practically unobtainable now, and many of these stoves have consequently gone out of use. To enable them to be again employed, Messrs. Condrup, Limited, of 78, Fore-street, London, E.C. 2, have brought out a paraffin starter to replace the spirit starter. This comprises an annular dish which replaces the former spirit dish below the burner, and contains an asbestos wick. A small quantity of paraffin is placed in the dish and burns from the wick, heating the main burner to the required temperature.

Mr. Auguste J. Rossi, Perkin Medallist.—The Perkin medal of the New York Section of the Society of Chemical Industry was, this January, presented by Dr. W. J. Nichols, a past-president of the society, to Mr. Auguste J. Rossi, of Niagara Falls, for his researches on titanium and other iron alloys. Rossi was born in France, and went over to America in 1859, when 20 years old. He became connected with the Boonton Iron Works, which smelted chiefly iron ores from New Jersey, which were all titaniferous and hence supposed to give a very pasty slag. Rossi did not experience any difficulty with the titanium. But the works were closed for other reasons, and later, in the 'nineties, when rich titanium-iron ores were mined in the Adirondacks, Rossi concentrated his attention on the reduction of titanium in the electric furnace since carbon does not reduce titanium in the blast furnace. The ferrotitanium he made with the aid of carbon and graphite electrodes not being free of carbon, he turned the titanium oxides, without carbon, directly into aluminium (fused by the current) and thus obtained titanium (and also tungsten) alloys containing up to 85 per cent. of these metals. Titanium was valuable as a scavenger for oxygen and nitrogen in steel and in copper, Rossi found, and it improved and hardened rail steel and steel in general. Later, Rossi became interested also in the liquifaction of gases.

THE IRON CARBON EQUILIBRIUM DIAGRAM AND ITS PRACTICAL USEFULNESS.*

By Professor H. C. H. Carpenter, M.A., A.R.S.M., M.I.M.M. (Royal School of Mines).

In the opening words of his paper on "The Strength and Inner Structure of Mild Steel," presented to the Institution of Naval Architects last year, Professor Dalby wrote as follows:—"In recent years the study of the inner structure of metals has changed from an interesting research in pure science to an industrial research of profound importance to engineers. Knowledge is steadily being accumulated of the inner architecture of metals; of the effect of heat treatment on the style of the architecture of the true nature of alloys, and of the true nature of solidification of metals." And he went on to consider briefly the phenomena associated with the freezing and cooling of certain metals and alloys, and in particular of the pearlitic constituent of steels. As he pointed out in the concluding paragraph of the same paper, the structural changes that occur at certain critical temperatures in steels are associated with heat evolutions on cooling, and these form the basis of the data used in the construction of the temperature concentration diagram of iron and carbon. In fulfilment of a promise made a year ago, the following paper has been written with a twofold aim:—

1. To show briefly how the temperature concentration or equilibrium diagram has been constructed; and
2. To illustrate its practical usefulness to the engineer.

Professor Dalby's opening words are profoundly true. Fifty years ago almost nothing was known as to the internal architecture and constitution of metals and alloys. The science of metallography had not been born. To-day we stand in possession of a vast storehouse of scientific knowledge, both practical and theoretical, bearing on what may be called the life-history of many of the industrial alloys, and most of all of those alloys of iron and carbon known as steels. We know not only how but why their behaviour in practice depends on the way in which they crystallise after being cast, on the conditions under which they cool to the ordinary temperature, and on the particular thermal and/or mechanical treatment they may subsequently receive.

To take a particular instance, we know why, in the hardening of tool steel, a particular and very narrow range of temperature must be adopted if the best results are to be obtained, and why inferior results are obtained both above and below this. We are also getting to know something of the causes of failure in practice of those metals and alloys which are designated "mysterious," whose number, therefore, is gradually diminishing. Further, we can usually predict in the case of new alloy systems, whose properties have not been investigated, the compositions which will repay scientific and technical research. In a word, whereas metallurgy is one of the oldest of the arts, it is only within the last half-century, and indeed almost within the last thirty years, that the scientific bases of that art have been discovered and firmly established. And the most powerful weapon at the command of the new science is the thermal equilibrium, or constitutional, or temperature concentration diagram. Without this no metallurgical practice, however skilled, can be other than empirical. Without this the best can never be got out of any industrial metal or alloy. With it complete confidence may be felt that ultimately the very best practice of which any such metal or alloy is capable will be reached. Although, therefore, it is essentially a scientific weapon, to obtain which the greatest care is necessary, it is of absolutely indispensable practical importance.

The thermal equilibrium diagram of a binary alloy whose co-ordinates are temperature and concentration shows graphically and at a glance exactly what constituents or phases, as they are called—the term will be defined later on—are present in the alloy at any given temperature and for any particular concentration when the system is in thermal equilibrium. It also shows the range of composition and of temperature over which a particular constituent can exist. It shows further the boundary surfaces between the various phases, whether they are vertical, horizontal or sloping.

This diagram can be established in any given case by suitable experiments, and these fall under two general heads: (1) By the use of the method of thermal analysis, and (2) by the study of the structure after the alloy has been treated so as to bring it into thermal equilibrium at the temperature in question. The former requires the use of high-temperature thermometers or pyrometers, and involves the taking of heating and cooling curves; the latter demands the preparation of the alloys for microscopical examination. The function of the former is to detect the thermal change which occurs either on heating or cooling; that of the latter is to interpret what the change is. There are cases in which other methods of study find application, depending on the measurement of electrical, magnetic, or thermal conductivities or volume changes, and these may afford valuable information where the indications of thermal analysis and microscopic examination are somewhat indecisive, but in the great majority of instances these two experimental weapons are sufficient for determining the equilibrium diagram. They, and they only, will therefore be briefly treated before passing to the particular case of the iron carbon system. Even these, however, cannot be satisfactorily treated until the principles of phase equilibrium and the requirements of the phase rule have been set forth.

The components of any system are the pure metals.

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* Paper read at the Spring meetings of the fifty-ninth session of the Institute of Naval Architects, March 21, 1918.

The phases are the homogeneous portions of the system which are separated from each other in space by bounding surfaces. The phases may be gaseous, liquid or solid. The number of "degrees of freedom" of a system is "the number of variable factors, temperature, pressure and concentration of components, which must be arbitrarily fixed in order that the condition of the system may be perfectly defined."* What the phase rule states is that if p be the number of phases, n the number of components, and f the number of degrees of freedom then

$$f = n - p + 2$$

when the system is in equilibrium. Accordingly the greater the number of phases present in any given system the fewer are the degrees of freedom. In most alloy systems, and certainly in that of iron and carbon, consideration of the vapour phase and the effect of changes of pressure can be omitted. This accordingly reduces the number of variables to two, viz., temperature and concentration. In this case

$$f = n - p + 1$$

represents the conditions of equilibrium, and this is the form that can generally be applied to the study of alloy systems.

Let a two-component system be considered. If only one phase is present, the liquid (*i.e.*, if the alloy is melted and the components are miscible), we have—

$$f = 2 - 1 + 1 = 2.$$

The system has two degrees of freedom, and is said to be bivariant. This means that both temperature and concentration can vary independently without altering the number of the phases. Suppose the liquid cools and reaches the freezing-point. Two phases are now present, liquid and solid, and we have—

$$f = 2 - 2 + 1 = 1.$$

In this case the number of degrees of freedom is only one, and the system is therefore univariant. If the temperature is changed there will be a corresponding change in the composition of the mother liquor or liquid phase. Cooling the alloy will cause a further deposition of the solid which, for the sake of simplicity, may be represented as one of the pure metals. Let the alloy be cooled still further until it reaches the temperature at which the second metal deposits. Three phases are present, two solid and one liquid, and we have—

$$f = 2 - 3 + 1 = 0.$$

The number of degrees of freedom is zero, and the system is said to be non-variant or invariant. In other words, equilibrium between the three phases is possible only at one temperature. If the latter is raised, one solid phase disappears, if it is lowered the liquid disappears. Both composition and temperature remain constant during the process of solidification. These considerations require to be borne in mind and rigidly applied in the construction of the diagram of thermal equilibrium. More confusion of mind has existed and still exists with regard to the number of phases present in any given alloy system owing to a lack of application of the phase rule than from any other cause. It is the sheet anchor of the equilibrium diagram.

Let us consider next the means adopted to obtain the experimental data upon which the equilibrium diagram is based. We require methods of measuring the temperature of our alloy, of following the rate of cooling from the molten condition down to a point which is below any critical change and also of estimating the rate of heating the alloy from the ordinary temperature up to the melting-point if necessary. These furnish the data from which the construction of the diagram can be begun. Temperatures are most conveniently determined by thermojunction pyrometers, usually of platinum and an alloy of platinum and iridium or rhodium, in which what is actually measured is the electromotive force, and this is converted into temperature (degrees Centigrade) by means of the general expression—

$$E = a + bt + ct^2,$$

where E is the electromotive force, t is the temperature, a, b and c are constants which require to be determined for each particular junction. Details of the potentiometer used by Mr. Keeling and myself for measuring the E.M.F.'s in our research on the iron carbon equilibrium will be found in Vol. I of the "Collected Researches of the National Physical Laboratory," pages 227 to 244.

It is convenient to adopt one of two different methods for the cooling and heating curve work, according to the particular requirement. If it is desired to determine the temperature at which solid is first deposited from the molten alloy and to follow the freezing of that solid until the liquid has disappeared, it is obviously necessary to have a containing vessel, such as a crucible, for holding the alloy in the molten state. Into this when the requisite temperature has been reached, which should as a rule be from 100 deg. to 200 deg. C. above the freezing-point, the thermojunction, protected by a thin fireclay or silica sheath, is inserted, and then the rate of cooling followed by a stopwatch or, better still, a chronograph which marks seconds on a tape. In this way the time taken by the specimen to cool through any given interval can be measured. If time and temperature are then taken as the co-ordinates and the values of θ (temperature) and t (time) are plotted against one another we have in the case of an alloy which undergoes no change of state and no polymorphic change a curve represented by B (Fig. 1). If, however, changes of this kind occur, a curve of the type represented by A is obtained which in this particular case shows two breaks caused by evolutions of heat. This method obviously gives "time-temperature" curves.

If, however, the values of t for a given temperature interval be read off from the curve A and the differences are tabulated, a further series of numbers is obtained, and the differences between successive values then represent the time required to cool through that temperature interval, and these may be represented by $\frac{\Delta t}{\Delta \theta}$

Plotting these against θ gives the curve shown in C which is called an "inverse-rate" curve. The effect of this, as will be seen, is to accentuate the arrests on the cooling curve and to bring them into greater prominence. While this modification has this obvious advantage, it has the drawback that the shape of the curve depends to some extent on the particular temperature interval chosen. This, however, is a matter which presents no difficulties provided the interval chosen be small enough, *e.g.*, 2 deg. C.

When, however, it is required to ascertain whether any critical changes occur in the cooling of the solid alloy down to the ordinary temperature, where, as a rule, the heat evolutions are weaker than those that accompany a change of state, it is convenient to adopt what is called the differential, or more accurately, the difference, method of cooling or heating. In this case the temperature of the alloy is compared at intervals with that of a "neutral" body which is known to possess no critical points in the temperature interval examined. This arrangement is shown in Fig. 2. The data obtained in this way are $\theta - \theta_1$, in which θ is the temperature of the alloy being investigated and θ_1 that of the neutral body. If these are plotted against θ the "difference" curve shown in D is obtained. Finally, if the co-ordinates taken are θ and $\frac{\Delta(\theta - \theta_1)}{\Delta \theta}$ the "derived differential" curve shown in E is obtained. This method is much more sensitive than the direct one, and with proper care can be made to yield information as to faint thermal changes which the latter would fail to detect. Curve E bears the same relation to curve D that curve C bears to curve A, and the similarity between C and E is very striking. But again it must be emphasised that both of these depend on the temperature intervals chosen for comparison, whereas A and D do not. For this reason on the whole I prefer to give results in the latter form and this method will be adhered to in the present paper.

Fig. 1. (AFTER DESCH).

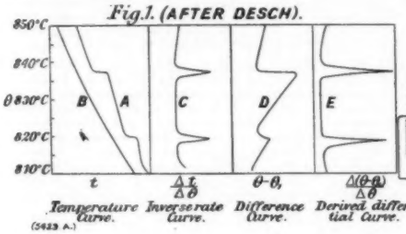


Fig. 2.

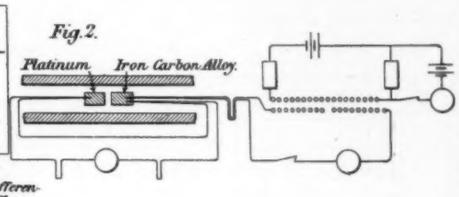
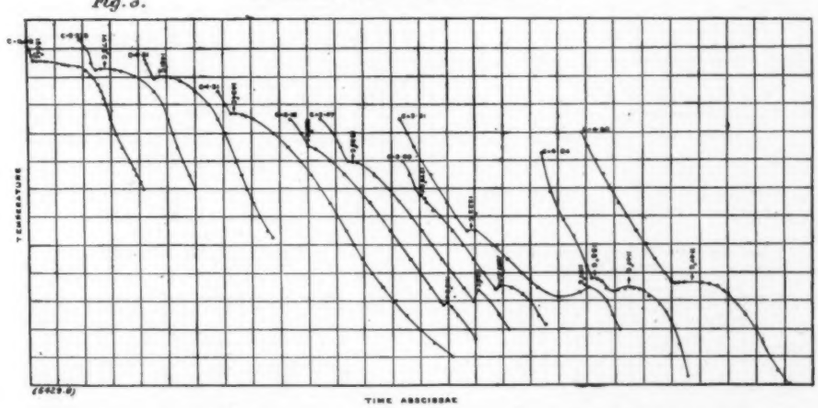


Fig. 3. COOLING CURVES OF THE LIQUID ALLOYS.



These two methods when properly used give the fundamental data for the equilibrium diagram in any given case. They presuppose that in all cases a suitable rate of cooling or heating is adopted so that there is no question of a change being suppressed by a too rapid change of temperature. While, however, the direct method gives in the case of a series of alloys, *e.g.*, of two metals, a number of freezing-points where solid first separates on cooling, which, when joined together, constitute what is called the liquidus curve, and somewhat less certainly a number of points where freezing stops and the last trace of liquid disappears, which when joined up constitute the solidus curve, neither it nor the difference method does more than establish the existence of certain heat changes on cooling—provided they occur at all—in the solid alloys. Neither of them gives any information as to what may be called the meaning of the thermal changes, and it is here that the second experimental weapon is required, viz., the microscope, which can, in the great majority of changes, be made to yield the necessary information. In a word, the pyrometer detects the changes, the microscope interprets them.

With regard to the latter, I must assume that my readers are familiar with the methods of preparing metals and alloys for microscopic examination and revealing their structure after that preparation. It is necessary, however, that a few words should be said as to the conditions which must be observed if the microscope is to furnish the necessary elucidation of the heat changes. Here, again, much confusion has existed in the past because it has not always been realised what the conditions are. In constructing the diagram the microscope is called upon to give information as to the phase or phases present in any alloy, not only at the ordinary temperature, but at any point up to the liquidus. As the specimen cannot be examined at any but slightly super-atmospheric temperatures, it has somehow to be preserved in that condition so that it can be examined at ordinary temperatures. The method universally adopted is: (1) To heat the alloy to the required temperature and maintain it there sufficiently long for thermal equilibrium to be reached, and (2) after this is the case to chill it so rapidly, *e.g.*, by quenching it in water just above 0 deg. C., that no thermal change can take place. If this is achieved, there is no fear that any change will occur, because molecular mobility in alloys is very slight at the ordinary temperature.

With regard to condition (1), it will be obvious that unless it is realised faulty deductions will be liable to be made. As a rule the further the alloy is situated from the end members of the series—the pure metals—the longer the time required for complete diffusion of the constituents and the attainment of thermal equilibrium. As regards (2), this requires that the specimens chosen shall be sufficiently small for rapid chilling, and that their surfaces shall not be oxidised, otherwise conduction of heat to the chilling liquid will not be rapid enough. The specimens, therefore, should either be heated in a neutral gas or, better still, heated and quenched *in vacuo*. In the latter case they are heated in an evacuated fused quartz tube into which water can be introduced at the required moment, an ingenious method introduced by Dr. Rosenhain.*

If the specimen has been heated in air it is certain to undergo a change of composition. But even if it is heated either in a neutral gas or *in vacuo* the surface layers may suffer a change of composition if, *e.g.*, one of the constituents has a greater vapour pressure than the other and therefore vaporises at a faster rate. Accordingly the safest plan is to grind off sufficient of the outer layers to get rid of the altered material before actually polishing, etching and examining the specimen. With the observance of this precaution the structure observed may be taken as typical of the alloy at the quenching temperature.

Assuming now that it is desired to find out what change takes place in the structure of a given alloy at a particular thermal evolution, all that is necessary is to quench two specimens with the above precautions, the one just above and the other just below the heat evolution in question. It may not be always possible to deduce this from the behaviour from one particular alloy, but it can generally be done if experiments are made on several alloys in that neighbourhood. In this

* Findlay, "Phase Rule," page 15.

* Journal of the Iron and Steel Institute, 1908, I, Vol. page 87.

way the cumulative effect of the evidence afforded by the two series of structures can generally be made to give the required information. By this means the interpretation of each heat evolution can be worked out, and this completes the evidence required for the construction of the diagram.

The complete diagram of a series of alloys whose co-ordinates are temperature and concentration is composed of a number of lines and areas. The lines composing it and bounding the areas of phase stability are as follows (neglecting, as usual, the vapour phase): "(1) The freezing-point curve or liquidus; (2) the solidus, which is also regarded somewhat loosely as the melting-point curve; (3) curves of liquid solubility separating the regions of immiscible liquid phases; (4) horizontal or inclined lines, representing the transformations of solid phases, such as the polymorphic changes of crystals, the formation of compounds from solid constituents, and the separation of new phases from solid solution; (5) vertical lines representing the limits of concentration between which the solid phases occurring in the system are stable in contact with each other. When the phases in question are not pure metals or compounds but solid solutions these dividing lines are slightly inclined, since the limits of saturation vary to a slight extent with the temperature."* "The diagram has certain inevitable limitations. It is essentially an equilibrium diagram; that is, it represents the limits of temperature and composition within which each phase is in the strict sense of the word stable. But stability presupposes equilibrium conditions. An alloy may prove on examination to differ widely in properties from an ideal alloy, having the same composition and the same temperature, but its condition then is not one of stability. The changes necessary to reach a state of stability may proceed so slowly, on account of the low velocity of diffusion, that the alloy may present a false appearance of being in equilibrium. Experiments continued over a long period may be required to determine the true equilibrium." Once constructed, however, an inspection of the diagram "affords at least qualitative information as to the metastable and labile conditions which may be obtained by rapid cooling."†

With this brief introduction we can now proceed to consider the construction of the iron carbon diagram itself. This diagram in the form in which it is now generally accepted is the result of the labours of many investigators. Even now, in spite of the large amount of work done on it, it cannot be said that a complete interpretation of all the facts known in connection with wrought irons, steels and cast irons has yet been found. In regard, however, to the essential features of the diagram—and particularly as regards the whole range of steels, which constitute more than 90 per cent. of the finished products obtained from the iron annually smelted from its ores—the interpretation is on the whole established by such a mass of evidence as to warrant the utmost reliance being placed upon it.

The first attempt to determine experimentally the thermal data needed for the construction of the iron carbon diagram over the complete range 0 per cent. to 4·5 per cent. of carbon was made by Mr. Keeling and myself in the years 1902–04, and our results were published in the Journal of the Iron and Steel Institute in the latter year (No. 1, pages 224 to 242). Previous to this many investigators, including the late Dr. Sorby, M. Osmond, and Sir William Roberts-Austen, and, among the living, Stead, Stansfield, Arnold Le Chatelier, and Howe, had carried out valuable pioneering work principally on the microscopic structure of steels and irons. Le Chatelier, Osmond, Roberts-Austen and Stansfield, however, had begun the thermal study of iron carbon alloys, and sufficient data had been accumulated to enable the Dutch chemist Roozeboom to construct the first equilibrium diagram. Complete uncertainty, however, existed as to the form of the liquidus and solidus of nearly all the industrial steels and the freezing-point of iron itself had only been guessed at. (Our subsequent investigations showed that it had been placed about 100 deg. too high.) While, therefore, the microscopic evidence was good, the thermal evidence was incomplete. And this was due to two causes: (1) The uncertainty in the temperature scale above 1,200 deg. C., and (2) the difficulty of melting alloys where temperatures up to 1,600 deg. C. were required, and taking cooling curves from those temperatures. For this reason we concentrated our efforts on obtaining accurate thermal data of the whole range of alloys from 0 per cent. to 4·5 per cent of carbon, from the liquidus downwards.

The diagram constructed from our thermal data which could be interpreted by the aid of the microscopic evidence already existing is, so far as its main features are concerned, generally accepted to-day. It is quite true—and we were careful to state it in our paper—that more uncertainty existed with regard to a part of the solidus line (where freezing ends on cooling) than with regard to the other lines, and we put the uncertainty at from 20 deg. to 30 deg. C. The reason for this uncertainty is that it was more difficult to estimate where the cooling curve rejoined the original slope than where it departed from it, the end of freezing in this range of composition not being well marked. Subsequently, a Russian investigator, Gutowsky‡ attempted to determine the solidus by quenching experiments, and on the basis of his data drew a curve somewhat lower than ours and rather more concave upwards. With regard to this Dr. Stead wrote§: "Gutowsky, as the result of his researches, has considerably altered the line of final solidification. The method he used is theoretically correct, but the results should only be accepted tentatively, until further confirmation, in view of the fact that they appear to be contrary to practice and to what one would reasonably expect." This being the case, I propose to adhere to the curve obtained from our solidus from 0 per cent. to 2 per cent. of carbon, it being understood that there is still some uncertainty about its exact form.

Full details of our investigation will be found in our published paper. My object now is to give only sufficient data and their interpretation to render intelligible the construction of the diagram itself and to enable it to be used. Between the limits of 0 per cent. and 4·5 per cent. of carbon we prepared and investigated no less than 38 alloys corresponding to an average difference in successive alloys of about 0·12 per cent. As far as possible all other constituents liable to occur even in the purest irons and steels were kept low and constant.

Typical curves obtained by both the direct and the difference methods will now be given. The former were used for determining the liquidus and solidus, the latter for detecting and locating transformations in the solid alloys.

Cooling Curves of the Melt.—A series of 10 of these are shown in Fig. 3, proceeding by steps of about 0·5 per cent. of carbon. Starting from the left-hand side of each curve, the point where it bends to the right and forms either a platform or gives place to a much retarded slope is the place where freezing begins and crystals separate in the melt. The freezing range widens up to about 2 per cent. of carbon, at which composition it is no less than about 250 deg. C. From here onwards it diminishes, and at 4·3 per cent. the alloy solidifies at one temperature. There is no uncertainty about the solidus between 2 per cent. and 4·3 per cent. of carbon, because this is always marked by a recalescence which will be seen on each of the curves at temperatures between 1,105 deg. and 1,135 deg. C., and this temperature is nearly constant (theoretically it should be absolutely constant, and the inconstancy is due to super-cooling effects in the alloys where it first appears). When the carbon content is less than 2 per cent., however, there is no recalescence at the solidus. With low carbon content the change in slope is fairly well marked and the uncertainty is probably not more than about 10 deg. C. As 2 per cent., however, is approached the change in slope is less well-defined and the temperatures are in doubt to the extent of 20 deg., or even 30 deg. C.

Cooling Curves of the Solid.—A series of 16 of these is shown in Figs. 4 and 5. These were obtained by cooling the alloys against the metal platinum, which, so far as thermal evolutions are concerned, is a neutral substance, possessing none between 1,000 deg. and 500 deg. C., which is the range experimented over. As to these curves a few words are necessary. In the case of two metal cylinders of equal size, specific heat, and emissivity and in a uniformly heated furnace, the cooling curve would in the absence of thermal evolutions, be a vertica

Fig. 4. COOLING CURVES OF THE SOLID ALLOYS.
DEFLECTIONS OF THE DIFFERENTIAL GALVANOMETER PLOTTED TO SCALE.

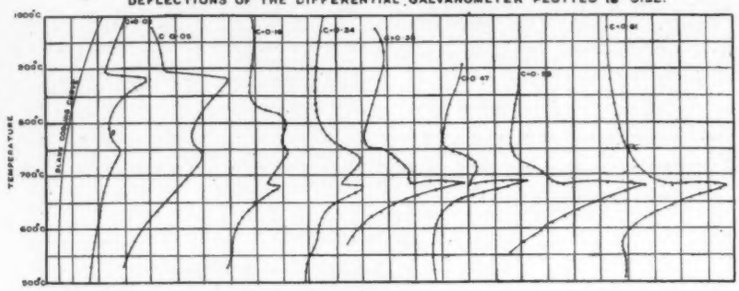


Fig. 5.

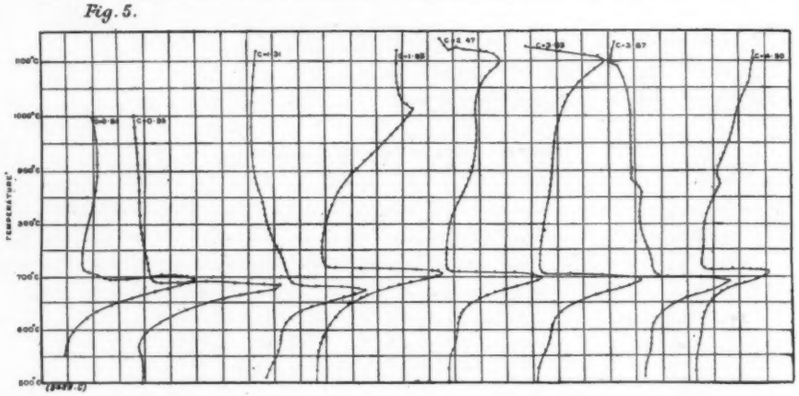


Fig. 6. OBSERVED EVOLUTIONS OF HEAT ON COOLING.

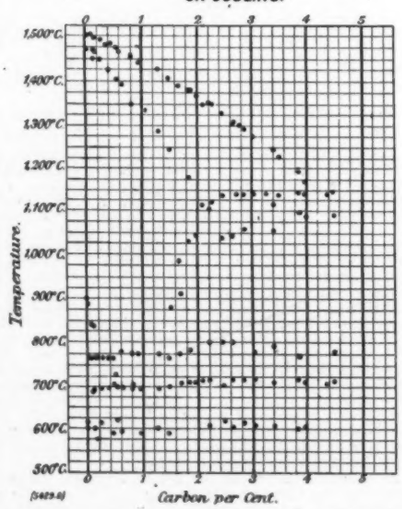
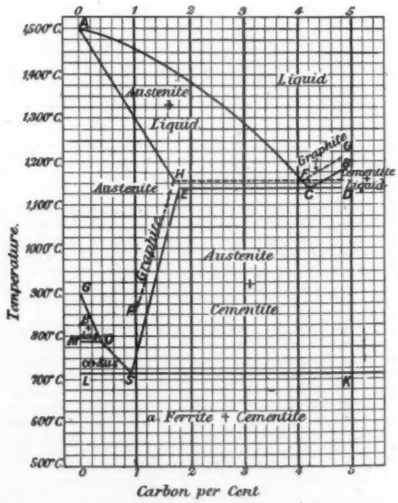


Fig. 7. EQUILIBRIUM DIAGRAMS.



* Desch, "Metallography," page 299.
† *Ibid.*, pages 301 and 302.
‡ *Metallurgie*, 1909, 6, pages 731, 737.
§ Trans. North-East Coast Institution of Engineers and Shipbuilders, vol. xxix, page 7

straight line; and if these conditions were not fulfilled the cooling curve would be smooth, approximating to a straight line but inclined to the vertical. This we showed by taking a cooling curve with nickel and platinum as the metals, both of which are neutral in this range. This curve was inclined to the vertical, but no departure from a straight line was noticeable. In every case two and sometimes three, and even four, curves were taken, the positions of the cylinders being altered between each determination. In the diagram the temperature of the alloy is plotted on the vertical ordinate, while differences of temperature, shown by the movements of the differential galvanometer, are plotted on the horizontal ordinate. Movements of the curve to the right indicate an evolution of heat in the alloy, and the extent to which the "peak" of the curve has departed from the normal slope is a rough, but not more than an approximate, measure of the magnitude of the evolution. As far as possible the experiments were so regulated that the normal slope of the curve was opposite to that which characterised a thermal evolution. In other words the normal slope was to the left. The majority of the curves fulfil this condition. If this is secured then the beginning of a thermal change is very sharply marked in most cases.

The thermal evolutions detected by this sensitive difference method are of two kinds. Some of them complete themselves within a narrow range of temperature, and these are, as a rule, of considerable magnitude. Others, on the other hand, spread themselves over a considerable temperature interval, and are usually less strongly marked. These two types are in fact illustrated by pure iron itself. If the cooling curve of the nearly carbonless iron (containing only 0·02 per cent. of carbon) be examined, it will be found that two heat evolutions are manifested. The one which begins at about 900 deg. C. and reaches a maximum within 10 deg. begins to die away shortly afterwards. It is a quick, strong heat change, and is accompanied by a profound alteration in many of the properties of the iron itself. The other begins slowly at rather below 800 deg. C., does not reach its maximum till about 760 deg. C., and at about 740 deg. C. begins to diminish. It is a weaker heat evolution spread over a considerable temperature interval. Above this heat change the iron is non-magnetic, below it is magnetic. Occasionally, but by no means invariably, a small heat change is shown on the curve at about 600 deg. C., but as there are grounds for doubting whether it is a property of the iron at all (and not caused by an inversion of the quartz in the furnace itself) it is omitted from consideration. The iron at temperatures above the upper heat evolution is in what is called the γ condition or, more briefly, is γ iron. That which exists between the two evolutions is called β iron and that below the second evolution α iron. The upper change is called Ar3 (the symbol was proposed by Osmond and is derived from "arreter") and the lower Ar2. These are customarily designated the three allotropic forms of iron.

If the curve of the alloy containing rather more carbon, viz., 0·16 per cent., be inspected—and this material approximates to mild steel—it will be seen that no less than three heat evolutions are manifested. The first begins at about 872 deg. and reaches its maximum at 837 deg.; the second begins at about 771 deg. and reaches its maximum at about 750 deg. These are the Ar3 and Ar2 changes, the former of which is lowered by the presence of the additional carbon, while the latter is hardly affected. The third, and new, heat evolution begins at 697 deg. and reaches a maximum at 693 deg. This is the so-called Ar1 change.

Succeeding curves with ever-increasing carbon show that the uppermost heat evolution occurs at lower and lower temperatures and merges with the one below it (see the curve of the alloy with 0·47 per cent. of carbon). From here onwards this becomes less strongly marked, and at 0·93 per cent. it has practically vanished. On the other hand, the Ar1 change at about 700 deg. C. grows in intensity with each successive addition of carbon, and in the 0·93 per cent. alloy is of enormous magnitude. This is the so-called "recalescence point" which was first noticed by Barrett. It was Gore who first observed the momentary elongation of a stretched steel wire on cooling to this temperature, and Barrett on investigating the volume change noticed the glow. Strictly speaking, this phenomenon is due to under-cooling—i.e., to the fact that the steel has cooled past the transformation point, and there the heat developed is so large that it causes a considerable rise in its temperature. This rise, which is manifest on several of our curves, and notably on that of the 0·81 per cent. carbon alloy, may be as much as 10 deg. or 15 deg. C.

Comparison of Heating and Cooling Curves.

Carbon Per Cent.	Beginning of Heat Evolution.		Beginning of Heat Evolution.	
	Ar3. deg. C.	Ac3. deg. C.	Ar1. deg. C.	Ac1. deg. C.
0·01	901	908	—	—
0·02	900	900	—	—
0·05	905	908	—	—
0·38	—	—	724	724
1·85	—	—	718	729
3·98	—	—	728	728
4·50	—	—	715	728

If the various heat evolutions shown in the two sets of curves be plotted in a diagram with temperature and carbon concentration as the co-ordinates, we obtain the result shown in Fig. 6, page 394. This is the first step in the construction of the diagram itself. At this stage it is simply a record of experimental observations without any interpretation other than that the liquidus and solidus curves are characterised. In our experiments we took in certain cases not only cooling but heating curves. Theoretically the latter should give more accurate data than the former, as the tendency to superheat is usually less than the tendency to supercool. Practically, however, it is more difficult to get well-defined heating than cooling curves. The following table enables a comparison to be made both of the A3 and the A1 change. (The absorptions of heat on heating are characterised as Ac3 and Ac1.)

It will be seen from these figures that the differences between the temperatures at which the evolutions of heat occur on cooling and the absorptions of heat on heating are very slight. And it may be said that provided care is taken to ensure that the rates of heating and cooling are sufficiently slow, the two methods can be made to give substantially identical results. This being so, the data obtained from cooling curves with the above precautions combined with those from quenching experiments already alluded to are the fundamental "raw material" for the construction of the equilibrium diagram.

The next stage is shown in Fig. 7, page 394, in which lines have been drawn through the observed points, and the outline of the diagram is revealed. For the sake of clearness the dots have been omitted, and further, only those areas have been constructed whose interpretation is generally agreed upon. Fortunately, that part of the diagram relating to steels, i.e., over a carbon range from 0·1 per cent. to 1·8 per cent., is less complex than that concerned with the higher carbon ranges, where the cast-irons occur, and speaking from a practical standpoint, it may be said that the main features of the "steels" diagram have now been established beyond dispute. In other words, the alloys of iron and carbon with which the members of this Institution are most intimately concerned are well known as regards their constitution, and the changes they undergo on heating and cooling. This is not to say, however, that even now there is nothing more to discover about them.

(To be continued.)

THE DERWENT VALLEY WATER WORKS.*

By EDWARD SANDEMAN, M.Sc., M.Inst.C.E.

THE paper describes the works constructed by the Derwent Valley Water Board to supply water from the upper reaches of the River Derwent in North Derbyshire to the counties of Derby and Nottingham, the cities of Sheffield and Nottingham, and the boroughs of Leicester and Derby. The Board was formed by virtue of powers granted by Parliament in the year 1899, and the amount authorised to be expended on the works by the Board was 5,500,000*l.* and by the cities and boroughs 1,045,000*l.* The works authorised to be constructed included six reservoirs with a total storage capacity of 10,000,000,000 gallons, together with aqueducts, filter beds, service reservoir, railways, &c.

The highest and smallest of these reservoirs—the Ronksley reservoir—was subsequently abandoned, and in order to compensate for the loss of storage capacity sustained by this alteration, the Derwent reservoir was increased in size by raising the dam 23 ft. in height. By dispensing with this reservoir it was estimated that a saving of 200,000*l.* was effected. The sanction of Parliament was obtained to this alteration in the year 1901. In 1904 further powers were obtained to enable the Board to divert a length of 15 miles of aqueduct between Ambergate and the River Trent, The diversion shortened the line of aqueduct by 1¼ mile, avoided certain narrow roads in which the pipes would have caused inconvenience, and reduced the weight of the cast-iron pipes by 6000 tons. The reduction of weight was due to the fact that the original line lay in the valley, and the new line on the adjoining hillside.

The gathering ground is 31,946 acres in extent, and is situated on the southern slope of the Pennine Range, at an elevation varying from 500 ft. to 2,000 ft. It is nearly all in Derbyshire, only a very small area lying in Yorkshire. The rivers rising on the watershed are the Derwent and the Ashop. The water is very soft—2 deg. to 3 deg.—but it is discoloured by peat when in flood.

In order to ascertain the quantity of water available from the watershed, three referees were appointed, under the powers of the 1899 Act, to make observations of the rainfall and to fix the available quantity of water, of which one-third was to be the quantity to be delivered as compensation water to the River Derwent. They estimated the total available water at 45,629,000 gallons per day, which, after deduction of 15,209,000 for compensation, left 30,420,000 gallons per day for supply purposes. This result was based on the quantity running off the watershed in the driest three consecutive years.

The average rainfall on the whole gathering ground is approximately 47 in. per annum.

The works are intended to be carried out in three instalments. They are designed to deal ultimately with 33,000,000 gallons per day, of which 13,000,000 gallons will be obtained from the first instalment, and about 10,000,000 gallons from each of the two later instalments.

The first instalment of work, which has been already constructed, includes the Howden and Derwent reservoirs; the main aqueduct 28 miles in length, consisting of 4 miles of tunnels, 7 miles of covered conduits, and 17 miles of 45-in. pipes between Derwent reservoir and Ambergate: lines of pipes for the Sheffield, Derby, Leicester and Nottingham supplies collectively 23 miles in length; filter beds at Bamford, and a large service reservoir at Ambergate.

The Howden and Derwent dams are similar in section. The greatest height at any section above foundation level is 183 ft. The pressure on the up-stream toe with reservoir empty is calculated to be 9·23 tons per square foot, and on the down-stream toe 1·76 tons. With a full reservoir overflowing, the pressure are 4·2 tons on the up-stream toe and 7·43 tons per square foot down-stream. The maximum observed settlement of the masonry on the shale and sandstone foundations was about 1 in.

The dams are built of large, rough blocks of millstone grit, ranging up to 6 tons in weight, set in and surrounded by concrete. The concrete consists of six parts of an aggregate of stone and sand to one part of cement in the lower part of the dam, increasing in strength 5 to 1 in the upper part. The dams are faced with squared rock-faced stones 3 ft. in thickness, with joints ½ in. wide, caulked with neat cement on the up-stream side. The dimensions of the dams are as follows:—

	Howden Dam. Ft.	Derwent Dam. Ft.
Length	1,080	1,110
Greatest width at base ...	176	171
Height	117	114
Length of overflow ...	500	600
Depth of foundations ...	70	60
Depth of narrow trench ...	55	38
	Cub. Yds.	Cub. Yds.
Excavation	261,038	342,803
Masonry	306,057	378,288

The foundations of the dams are in beds of black shale and sandstone, which were very much contorted, broken and crushed. Headings driven into the hillsides failed to disclose any watertight strata, and consequently wing trenches, filled with concrete, had to be constructed on both sides of the Howden reservoir. They are about ½ mile in length. The maximum depth of trench on the east side of the reservoir is 190 ft., and on the west side 115 ft.

Owing to the strata dipping in two directions, the wing trenches at the Derwent dam were carried straight into the hillsides, in line with the dam, for distances of 792 ft. on the east and 605 ft. on the west side. The strata found were porous, and the wing trenches were continued for such long distances solely with the object of providing sufficient resistance to overcome the water pressure. The foundations of the trenches at the Derwent Dam were fairly satisfactory, and they were made good by injecting cement grout. The maximum speed obtained in building the Derwent masonry dams was 2,650 cub. yards in one week. The masonry dams were constructed by administration, but the aqueducts and other works by contract.

Records of the temperatures obtaining in the masonry were taken by means of thermophones at the Derwent dam between the years 1909–15. The thermophones recorded the temperatures at points varying from 1 in. within the masonry face to 30 ft. The maximum variation at 1 in. was 8.0 deg., but at 30 ft. it was not more than 7 deg. The results differed generally for the north and south sides of the dam, owing to the fact that the former was always in shade.

It was found that if—

D denotes the distance in feet inside the dam measured perpendicular to the face;
R denotes maximum range of temperature in degrees (Fahrenheit) at the distance D;
T denotes maximum range of temperature outside dam in the shade:

$$\text{For north side, } R = \frac{T}{1.85\ D^{0.38}}$$

$$\text{For south side, } R = \frac{T}{1.4\ D^{0.47}}$$

Records were also made of the movements of the dams caused by the filling of the reservoirs with water, and it was found that the maximum movement down-stream of the crest was 0·81 in. in the centre of the dam, and about half that amount at the two towers flanking the overflow weir.

A description is given of the gravel roughing filters and sand filters at Bamford, which are capable of dealing with 10,000,000 gallons to 11,000,000 gallons per day and also of the service reservoir at Ambergate, which has a capacity of 29,000,000 gallons. Particulars are given of the cost of the principal items of work forming part of the reservoir and aqueduct. The total expenditure upon the works amounted to 3,545,000*l.*

* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, April 9, 1918.

THE FORMATION OF DIAMONDS.—For the past thirty years, unknown to the scientific and engineering world in which, as the inventor of the steam turbine and other devices, he is so famous, the Hon. Sir Charles Parsons has been conducting experiments on the formation of the diamond. The results of his work in this fascinating field of research—work which has a direct bearing on many branches of pure and applied science—are to be made known for the first time at the eighth annual May lecture, which he is to give before the Institute of Metals, on May 2nd. In view of the special character of the occasion, the Council of the Institute of Metals have decided to make this an open meeting. Those desiring to be present, should apply—enclosing a stamped and addressed envelope—for cards of invitation to Mr. G. Shaw Scott, M.Sc., 36, Victoria-street, S.W.1, who will also be glad to supply particulars of membership of the Institute, a ballot for election to which is due to be held on April 24th.

THE LATE MR. ROBERT WINTHROP BLACKWELL.

By the sudden death of Mr. Robert W. Blackwell, after a very short illness at his residence, "Elmbank," Hampstead, on March 29, the electrical profession loses one of the few remaining and best known pioneers of electric traction, and one whose name has been intimately connected with the most important branch of electrical engineering both in the United States and in this country, for the last thirty-five years.

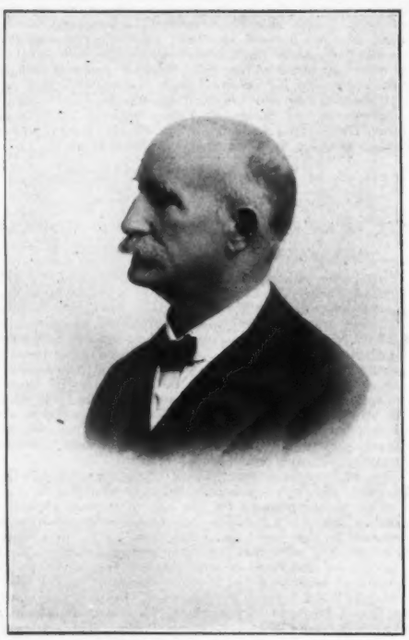
Born in 1858, Mr. Robert W. Blackwell graduated as M.A. and B.LL. at Princeton University, where he was a contemporary of President Wilson. He afterwards practised as a councillor of law at the American Bar. Attracted however by the great demand for mechanically operated street cars, the need for which was so urgently felt in the United States, he, jointly with Mr. Edward W. Bentley and Mr. Walter H. Knight, founded in 1883 the Bentley Knight Electric Railway Company, of New York, which installed and equipped an electrically operated tramway system in Cleveland, Ohio, this was opened for traffic in 1884, and was the first line to be operated electrically as a commercial undertaking.

Mr. Blackwell, as a contemporary of Sprague, Vanderpoel and Edison, was intimately associated with the great pioneer work carried out in the U.S.A. between 1883 and 1889. He was actively engaged in the management of his company until the latter date when he transferred the Bentley Knight Company's interests to the Thomson-Houston Company of Lynn, Mass. Mr. Blackwell was shortly afterwards summoned to England to give evidence before Parliament on behalf of the first Bill promoted by the Central London Railway Company, and it was the experience he gained during this stay which revealed to him the great prospects of electric traction in the United Kingdom. Eventually in 1890 he took up his residence in this country, and became associated with Messrs. Greenwood and Batley, of Leeds, in conjunction with whom he opened an office in London for the purpose of introducing electric traction on the tramway systems of the United Kingdom. Speaking about the United States before the Institute of Electrical Engineers in 1892, Mr. Blackwell said: "The public has thoroughly supported those tramways which have introduced electricity and has rewarded their enterprise by greatly increased patronage. That electric traction will receive the same acceptance here that it has already gained across the water, I do not doubt." Time more than justified Mr. Blackwell's anticipations, although several years of arduous pioneering work were necessary before electric traction was definitely established in this country. In 1894 Mr. Blackwell founded the firm of Robert W. Blackwell and Company, which, ever since that time, has been well known as one of the leading firms of merchant manufacturers, engineers, and contractors. All those who have dealt with this firm agree that it has deservedly acquired the reputation of standing second to none for the uprightness of its dealings and the quality of its work.

In 1895 Messrs. Blackwell and Company secured the contract from the British Thomson-Houston Company for the construction and electrical equipment of a new tramway in Bristol. The great financial success secured by this first electrification on a commercial scale, served as an incentive to many others to follow in the footsteps of the enterprising Bristol Tramways and Carriage Company, and Bristol was visited and the system inspected by delegates from all parts of Great Britain and the Continent as the model electric tramway installation to be admired and copied.

As engineers and contractors, Messrs. R. W. Blackwell and Co. were henceforth connected with a large majority of all the electric traction systems installed, amongst which may be mentioned those at Bradford, Bolton, Cork, Central London, Coventry, Cardiff, Chatham, Colombo, Dublin, Doncaster, Giants Causeway, Glasgow, Gateshead, Isle of Man, London United, Liege, L.C.C., Leicester, Lugano, Liverpool, Norwich, Nishni Novgorod, Nottingham, Plymouth, the Potteries, Perth, Reading, Southampton, St. Helens and many other British and foreign undertakings. They supplied materials and engineering advice to a large number of continental firms; they were the expert advisers on traction matters to such firms as the Oerlikon Company, Shuckert and Company, and Ganz and Company, and their design and specialities are to be found in a large number of electric tramway installations throughout Europe, Africa, Asia and South America. It was they who designed the originally successful trolley standards for top seat tram cars and who first standardised the pole and bracket arm construction for overhead lines. Wherever anything new was to be seen, or experience was to be gained, there Mr. Blackwell went or sent his engineers or representatives, to investigate and test, with the result that purchasers always came to him for information and advice. He showed in 1897, at the Brussels Exhibition, an exhibit which was one of the most interesting in the whole British section. He was a member of the International jury there.

It is interesting to note that although American born and a very prominent member of the American Society in London, all Mr. Blackwell's associates and staff were British and the prescience shown by him in selecting men, and the kindly assistance and advice and loyal support he always gave his staff, have resulted in the launching of a great many engineers into the prominent positions they now hold in many parts of the world. His firm carried out many important works for English railway companies, including the Great Western, the Great Central, and the London, Brighton and South Coast Railway Companies. The work carried out for this latter company included some of the most difficult bits of construction ever planned and erected, under the most unfavourable conditions. The work was carried out to the design and under the supervision of Mr. Philip Dawson, M.Inst. C.E., the consulting electrical engineer of the L.B. & S.C. Railway Company, who for the first fifteen years of Mr. Blackwell's activities in this country has been intimately associated with him. This line has now been under operation for over nine years, and thanks to the observation of the principles always inculcated on his staff by Mr. Blackwell, of never doing bad work, the results



MR. ROBERT W. BLACKWELL.

have fully justified the confidence placed in him by this company, and have falsified the many criticisms made against the adoption of the overhead system by them, as well as the prophecies as regards the high cost of maintenance, frequent failures and interruptions of service, made from so many sides, when the decision of the Brighton company to adopt the overhead system first became known. At the annual meeting of the Brighton railway on February 2, 1910, the chairman, Lord Bessborough, expressed his satisfaction at the admirable manner in which Messrs. Blackwell had carried out their portion of the contract and testified to the excellence of the overhead work and the perfection of their electrical work.

Not only as an engineer and contractor, but in many other directions, Mr. Blackwell showed an initiative by building up a most successful roofing business, the material being made in his own works; by the manufacture in this country of apparatus and materials which had previously had to be imported from abroad. He was for many years chairman of Messrs. Johnson and Phillips, the well known electrical engineers and cable manufacturers, and did very much to bring them to the high pitch of prosperity they have reached to-day. He was as much loved and respected by his co-directors and the employees of that firm as he was by those of Messrs. Blackwell and Company. He was engaged in pioneering industry, and keenly felt the error so often committed of imposing too stringent conditions, regulations and penalties on any enterprise, a practice which he justly contended was largely responsible for many industries in this country not making any sensible progress.

Mr. Blackwell had many outside interests which cannot be referred to here; sufficient be it to say that he was in charge of most of the arrangements for looking after the American Military Mission during their visit to this country, and that he was a great supporter of the American Red Cross and kindred societies. He was a member of the Royal Automobile Club and of the City Liberal Club, and always retained his membership of the Manhattan and University Clubs of New York. He was a prominent mason, was past master of the lodge of the Nine Muses and the founder of the American Columbia Lodge and was awarded London Rank for his masonic services.

His memory will be kept green on the hearts of all those who had the privilege of his friendship, and nothing is more characteristic of him than the opinion expressed by one of his oldest friends, "Blackwell was as straight as a die."

THE LATE MR. JOHN SHANKS BRODIE.

We regret to have to record the death, which occurred suddenly, last Sunday, of Mr. John Shanks Brodie, who since 1900 had been the borough engineer and surveyor of Blackpool.

Mr. Brodie was born on October 2, 1850, and received his scientific training at the School of Art and Sciences, Newcastle-on-Tyne, during the years 1866-70; he served his pupilage at the same time, under the late Mr. John Atkinson Harrison. Later he was assistant to the late Mr. George Laws from 1870 to 1872. From 1872 to 1877, Mr. Brodie was assistant engineer at Consett, under Mr. Charles P. Douglas, when he was engaged in the construction of railways, bridges, roads, main drainage and water-supply works, also on the construction of blast furnaces and steel works. Then, from 1877 to 1884, he was engineering assistant to the Corporation of Liverpool, under Mr. George F. Deacon and Mr. Clement Dunscombe, when he was engaged on tramway construction, in the provision of hopper barges for the disposal of the town's refuse, and on street improvement work. For the following sixteen years, from 1884 to 1900, Mr. Brodie occupied the position of borough engineer, harbour engineer and waterworks engineer at Whitehaven, where he dealt with the laying of new water mains; the raising of Ennerdale Lake, a work for which Messrs. T. and C. Hawksley were the consulting engineers; new harbour works; electric light and power installations, for which the late Mr. John Hopkinson acted as consulting engineer; and in the putting down of new main drainage and pumping machinery.

From 1900 down to the time of his death, Mr. Brodie was borough engineer and surveyor of Blackpool, in which position he carried out a large amount of work, among which may be mentioned new electric tramways; refuse destruction plant; new sea-walls and promenade; new main drainage and storm water outlets; roads and streets; sea-water pumping and distribution plant, &c. In our issue for November 29, 1912, we gave an illustrated description of the sea-walls constructed by the Blackpool Corporation since 1902, designed by Mr. Brodie, and executed under his direct supervision. On that occasion, we stated that it would be difficult to find around our coast sea-defence works which had been carried out in a more thorough manner than those at Blackpool. A special feature about the walls and aprons, to which we then called attention, was that they were faced with basalt columnar stone, undoubtedly the very best material with which to face a sea-wall, the hexagonal shape of the stone making also a good key.

Mr. Brodie was elected a member of the Institution of Civil Engineers in December, 1906.

DETERMINING THE DENSITY OF SEA WATER.—In oceanographic work density determinations have rapidly to be made on board ship. The ordinary hydrometer is unsuitable for this work because it is too much influenced by surface tension, superficial impurities, &c. Total immersion instruments have hence been used, for example, by Nansen, who varied the temperature of the water to be tested until the densities of the liquid and of the float were equal. Others have obtained equilibrium by causing a piece of iron attached to the float to be attracted by an electromagnet. In his research, A. L. Thuras, of the Bureau of Standards (Journal of the Washington Academy of Sciences, December 19, 1917), goes back to Nansen's idea. The sea water to be tested is placed in a test tube, 15 cm. high, 18 mm. diameter, suspended in a cylindrical water bath which is provided with two walls, of glass and copper, to serve as jackets, and a stirrer, and is heated by a small resistance coil. Into the water under test is dropped the float or "bobbin," a hollow closed cylinder of glass, which is weighted by some liquid to keep it upright. The bath is heated until the float rises and the test is then repeated on cooling until the float sinks again; the apparatus is so adjusted that the average bath temperature at which equilibrium is reached will be between 16 deg. and 40 deg. C. The underlying assumption is that all sea waters, though differing in density and composition, have nearly the same temperature coefficient of density; the density can be determined to the fifth decimal, but any gas bubbles would, of course disturb the test.

EMERGENCY REPAIRS TO A BATTLESHIP.*

By LIEUTENANT E. E. WILSON, U.S. Navy.

THE details of the work involved in the substitution by the ship's force of the Arkansas, of an electric motor for the wrecked starboard main circulating pump, have been here assembled for the reason that, while they demonstrate nothing new, at the same time they involve certain principles of electrical and mechanical engineering in a most instructive manner. In addition this work has emphasised one fundamental principle, namely, that all apparatus delivered to the service should be as near the commercial standard as possible, and that service operation should conform to the commercial standard, so that in emergency the resources of the whole country, rather than a limited reserve, are available for use. This point was demonstrated in the attempt to obtain a suitable motor from shore. Whereas most commercial motors are built for a voltage of 220 to 230, the navy power circuits carry 125 volts, so that it was impossible to obtain on short notice a motor fulfilling the requirements. Instead, it became necessary to adapt one of the ship's motors to the service, and take extraordinary precautions to maintain it in operation.

The main circulating pumps of the Arkansas are of the centrifugal type, and are driven by impulse turbines manufactured by the Terry Steam Turbine Company, of Hartford, Conn. The turbines developed about 75 i.h.p. at 600 r.p.m. when driving the pumps. Steam is taken from the auxiliary steam line at boiler pressure and expanded in the nozzles down to the back pressure of the auxiliary exhaust, about 15 lb. gauge. Consequently the casing is not ordinarily subject to greater pressure than this back pressure and is designed on this basis. A relief valve, 3½ in. in diameter, is fitted to the exhaust side of the casing and set to lift at 20 lb. gauge. At the time of the accident the pumps were being secured. The machinist had closed the throttle by hand, and, upon seeing the pump stop, had closed the exhaust. Seeing steam leaking from around the glands, he started to close the throttle with a wrench, but before he could do so, the turbine exploded, blowing out the exhaust side of the casing as shown in Figs. 3 and 4, page 400. The relief valve had been frequently lifted by steam before the accident and afterwards relieved at a pressure of 20 lb. gauge.

Examination of the turbine showed it to be damaged beyond repair by the ship's force, though the casing itself was the only part rendered unfit for use. Steps were immediately taken to rig some sort of substitute, and, in the meantime, the two condensers were cross-connected by way of the main drain, so that the one circulating pump remaining could serve both condensers. This method limited the ship's speed to about 10 knots, with circulating water at the temperature of that locality, about 74 deg. F., though this speed could have been increased a knot or two with the colder water of higher latitudes.

Two alternatives presented themselves, (1) to drive the pump by chain or gearing from the main turbine shaft adjacent, and (2) to remove the old turbine and install a motor in its place. Of these (2) seemed the simplest and most reliable, provided a suitable motor could be had. Inquiry at the navy yard at Norfolk developed the fact that while no motor at 125 volts was available, there were several at 220 volts which might have been used. In order to use these, however, it would have been necessary to alter the armature circuits of one main generator, connecting the two windings in series rather than in parallel as they ordinarily are, so that the terminal voltage would be 250 instead of 125 volts. This method of operation was not an attractive one for the reasons that one generator would be required for the service of the pump alone, and that a separate circuit would be necessary from the dynamo rooms to the motor.

Since no suitable motor was available from an outside source, it was decided to take one from the ship itself. Investigation developed that the largest motor available was rated at 35 h.p., or about half that of the turbine. There were three types of motors of this capacity: (1) A shunt motor built for continuous service at 900 r.p.m., (2) a series motor built for intermittent service at 350 r.p.m., and a compound motor for intermittent service at 350 r.p.m. The first belonged to a forced-draught blower, and was eliminated for the reason that 350 revolutions of the pump required the full power of the motor, so that it would draw an excessive armature current in its attempt to maintain rated speed. The series motor might have served, but it belonged on a boat crane and was very necessary to the ship for this service. The compound motor belonged to a deck winch aft, where it was used seldom and could therefore be dispensed with. In addition its speed-load curve was favourable, though the limits of speed variation were necessarily restricted. It was also easily accessible and was therefore chosen for the duty.

The electrical characteristics that entered into the choice are shown in Fig. 1. Here are plotted (not to scale) the curves of speed versus armature current of the different types of motor. It was estimated that about 350 r.p.m. of the pump would require 35 h.p. output. At 125 volts this would call for an input of 245 amperes with an assumed motor efficiency of about 85 per cent. From the curves it is seen that the shunt motor was eliminated right here because at 245 amperes it would ordinarily run at 900 r.p.m. However, when the pump was driven at 350 r.p.m. it would require the full motor horse-power. As a result of the low speed the counter E.M.F. would be so small as to permit an excessive armature current to flow, burning out the motor or blowing the safety devices. In addition to this it is evident that even if the motor had been able to carry this current, the shafting would have been over-stressed, because of the greater torque required to transmit the same power at the lower speed. As for the other two it is seen from the curves that both the series and compound motors were adapted, as their rated speeds and armature currents corresponded to the speed and horse-power of the pump. The disadvantage of these two motors, however, lay in the fact that they were designed to carry full-load current for intermittent service only, while in the new duty they must operate continuously. However, since they were fully enclosed on deck it seemed reasonable to suppose that if opened up and properly ventilated below so as to get the heat away,

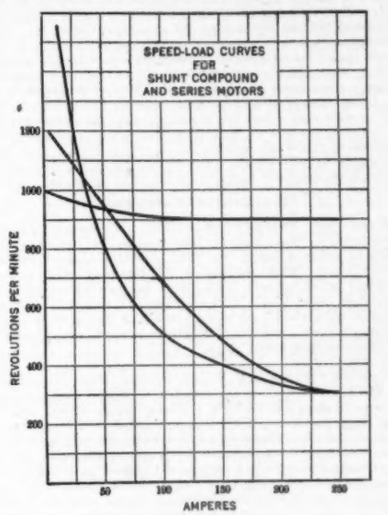


FIG. 1.

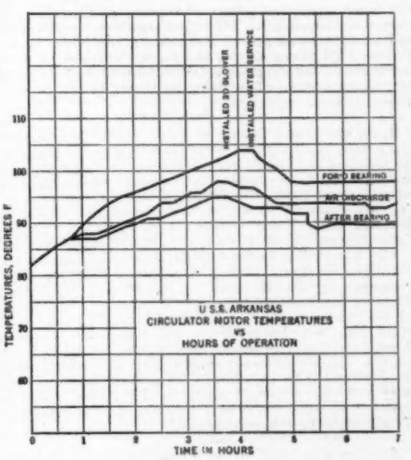


FIG. 2.

they would be able to stand the load without burning. On this assumption, the deck-winch motor was removed with its controller, thoroughly overhauled and started below.

In the meantime the turbine half of the flexible coupling for the pump was bushed and fitted to the armature shaft so as to render the coupling easy. At the same time the carpenter's gang had begun the installation of a wooden foundation of 6-in. by 6-in. timbers on the foundation of the circulating pump which had been removed. This foundation was set up as nearly in place as could be from measurements of the motor, and certain holes in the planking were slotted so as to permit of adjustment fore and aft and athwartships after the motor was located in place. Adjustment vertically was had by leaving the top timber a little low and shimming up with strips of sheet iron. This foundation seemed amply solid as the vibration from both motor and pump was negligible. Since the pump itself had two rotors on the same shaft taking water from both ends, the end thrust was balanced and there was no need of a thrust bearing or of any stiffness to take up thrust. The long bolts were made in the shop while the motor was being sent below, so that by the time the motor was ready its foundation was in place.

The repairs to the motor consisted of the renewal of a shunt fieldcoil, both bronze bearings and the armature, together with necessary varnishing and cleaning. The object of this work was to give the motor every chance to stand up under the work it was to do, and the necessity for these precautions became very evident when the motor was put in operation. At the same time it was much handier to send it below in sections as the distance from its old location to the new one was quite long. While the motor was being assembled in place the electricians were installing the starting rheostat and connecting the leads to the circuit for number six turret which passed through the wiring passage close by. A voltmeter and ammeter were installed in a convenient place, so that by the time the machinists had made the alignment everything was ready for operation.

In aligning the motor and pump use was made of the large flexible coupling. By means of the slotted bolt holes the motor was moved about until the flanges on the two shafts were parallel and their edges in line. After turning the motor over free to check the alignment, the coupling was bolted together and the motor started up. Predictions as to speed and load were immediately exceeded, as the pump was driven at 400 r.p.m. with 250 amperes at 120 volts, but the motor promptly began to heat. Inasmuch as the armature current was quite large it was assumed that the heating was due to this, but it soon became apparent that the trouble was in the bearings. Investigation showed that the new armature shaft had been made with the collars, which limited the end play, in such a position that there was no end play of the armature permitted. This was overcome by putting a gasket between the shields which held the bronze bearings and the casing, so that the end play became about ¼ of an inch. This relieved the difficulty when running free, but as soon as the pump was coupled up the bearing nearest the coupling ran warm again and the whole motor became quite hot. It was then observed that in drawing up the coupling the shoulder on the shaft was drawn hard against the bearing and that this was the source of heat. The coupling was then broken and the motor shifted toward the pump until, when the coupling was drawn tight, the armature end play was halved between bearings. As a result of this, the armature, while running with full load, worked fore and aft under the flexible coupling, so that it was not only free in its bearings but permitted a certain variation in the brush position on the commutator which was of value in keeping the latter cool. This eliminated all bearing trouble.

In the meantime every effort was being made to keep the motor cooled off. The commutator end of the armature was cooled by a blast of air from the ventilating system, which was led in by a canvas chute. The forward bearing was under a blast of the same sort. At both ends the blast as first installed blew directly across; but when this failed, holes were drilled in the forward-bearing housing, and the air which went in at the commutator end passed the length of the armature and out at the forward bearing where it met the second blast and was carried away. This, of course, made the air about the bearing very warm at the same time it was rubbing on the shoulder of the shaft. When, therefore, the adjustment was made for halving the end play, the process was reversed. The chute on the forward end was secured to the shield so that all its air was forced through the holes toward the commutator, where the blast from the second chute, sweeping across, carried it away (Figs. 5 and 6, page 400). This was fairly satisfactory, but, though the bearings remained cool, the heat was not getting away from the field coils and armature. A third air chute was then made to deliver a blast directly across the casing at its centre, and while this helped on one side the other was still warm.

Finally it was decided to resort to water cooling, and this was accomplished in a very simple way. First all possible leaks to the casing were plugged, then a ridge of putty was placed around the casing at each end. Next the intervening space was wrapped with a few turns of burlap and a small pipe was led from a handy salt-water pipe with a valve directly over the centre of the motor. From this source the burlap bagging was saturated, and as the air blast swept across the motor, the water was quickly evaporated. The heat necessary to cause the evaporation was taken from the casing itself, so that a rapid flow of heat from the coils and armature was established. Of course, the latent heat of evaporation being large, a much smaller amount of water was required than if the water simply ran over the casing and increase its sensible heat. It was possible, if desired, so to regulate the rate of flow to the casing that it was equal to the rate of evaporation, and thus prevent water from dripping to the deck. At any rate, the motor promptly cooled down and remained cool thereafter. Thermometers had been installed, one in each bearing, as shown in the pictures, and one in the path of the air discharged across the commutator. While these were not located to give accurate absolute results, still they were a good indication of the conditions at each place and thus were guides for operation.

When the installation was completed and found running well, an electrician's watch was established on the motor and a test begun. From the curves, Fig. 2, it is seen that the motor gradually increased its temperature along a typical warming curve; then settled down and maintained this temperature. The final temperature was that at which the difference between the motor and the outside air was such that the heat was radiated as fast as it was generated and equilibrium was maintained. The actual temperatures then were dependent upon those of the air supply, and it was found that the curve of temperatures followed that of the outside air while cruising. When the ship moved to northern waters, then motor temperatures went down promptly, and no more trouble was had from this source.

The change of latitude, of course, had the same effect

* We are indebted to the courtesy of the United States Naval Institute for permission to republish this article, which appeared in the January number of their Proceedings.

on the vacuum. The motor, operating at 400 r.p.m., was only 100 turns slower than the turbine on the other side. For a given speed the vacuum depends upon the temperature of injection, since the same quantity of steam condensed causes the same temperature rise and the higher the injection the higher the final temperature and the lower the vacuum according to the steam tables. It was expected that the temperature of the circulating water discharge would limit the speed of the ship, since the temperature of injection was high and the quantity of water circulated by the motor-driven pump was less than that of the turbine-driven unit. Were the temperatures allowed to become too high, damage might result to the condenser. At just what speed the temperatures would become too great was hard to estimate, but a glance at the trial data showed a 40 deg. temperature rise at 20·5 knots with 600 r.p.m. of the circulator. Assuming the rise to be directly proportional to the revolutions per minute, it appears that 60 deg. might be expected. However, it is well known that the frictional resistance in pipes varies as the square of the velocity of the fluid, so that at a rotor speed of two-thirds the trial speed, something more than two-thirds the quantity of water might be expected, resulting in a smaller rise than 60 deg. Again, since the power required per knot at high speeds may go up as the fifth power of the speed, it seemed likely that reducing the speed to 20 knots would reduce the rise very appreciably. Finally, if necessary, it was possible to make an average of 20 knots by making turns for 19 knots on the motor side and 21 knots on the other. Assuming a temperature rise of 50 deg., which was hardly to be expected, and placing the limiting temperature at 120 deg., which seemed safe, it was predicted that the ship could maintain 20 knots with an injection temperature of 70 deg., and her maximum speed of 21·50 knots with an injection of 55 deg.

Shortly after the motor was installed the ship began operations in connection with the strategical problem, but was not called on to make more than 17 knots before its completion. While proceeding to port, however, the commanding officer, desiring to determine exactly what could be done, ordered a 2-hour, full-power trial. By this time the motor had settled down to a steady temperature difference above the outside air, and was running well at about 395 r.p.m. Watching the discharge temperatures carefully, the speed was increased to 20 knots, and maintained for 2 hours, with a temperature rise of about 44 deg. on each side, the port shafts making about 5 r.p.m. more than the starboard. At the end of the 2 hours the throttles were opened wide for 10 minutes, during which turns for over 20¼ knots were maintained on both engines, with a temperature rise of 50 deg. in the starboard condenser. This confirmed the estimate based on the law for friction in pipes, and since by this time the ship was in the latitude of New York and the injection was 54 deg., the final temperature was but 104, leaving a wide margin had it been necessary to work up to the maximum speed. Upon arrival in port the motor was shut down after over five days' continuous operation, being in condition to continue indefinitely.

The motor having proved successful, there were consequently many people who advocated the installation of motors for this service in place of the old turbines. Against this proposition there were two important arguments. In the first place the engines became dependent upon the operation of a generator at a distance from them, over which the engine-room force had no control. The blowing of a circuit breaker or an accident to the generator would stop the flow of water through the condenser, and such an accident while operating at high powers might result in burning up the condenser before the engines could be stopped. To avoid this, two generators were kept in operation and a careful watch was stood at all times. A signal was arranged between the pump and throttle, so that if the motor stopped for any reason, the officer of the watch would be warned in time to shut down the engines and save the condenser. If through design or accident the power were shut off the motor circuit and the motor thus stopped, then before the operator could throw the rheostat to "off," the power were cut in again, there would be a dead short across the armature which would draw a large current and at best blow all the safety devices in the circuit. Against this the operator was carefully instructed and drilled. Unreliability, then, militates against the motor.

Even if the motor were practicable it would not be desirable. It is easily estimated that the motor would require about half as much steam as the turbine, and thus have the advantage. However, the steam leaving the pump turbine is not wasted. Part of it goes to heat the feed water, and the rest does work in the lower stages of the main turbines. It is likely that a pound of steam that enters the circulator turbine and expands down to the back pressure of the auxiliary exhaust, then passing to the main turbines, expands again to a very small back pressure in a turbine capable of utilising a big vacuum, does quite as much work as another pound that goes through the turbine of a 300-kw. generator operating off its best load. Each of these pounds gives up its latent heat of condensation to the circulating water where it is lost. That portion of the steam that goes to heat the feed water, however, does a certain portion of its work in the turbine; then passing to the feed heater, gives up its latent heat of condensation to the feed, whence it is returned to the boilers and saved. These facts account for the general principle, often enunciated in power-plant practice, that economical auxiliaries which rob the feed water of heat it might use, are not economical at all.

Summary.—The above description of the installation shows the following general principles to have been utilised: (1) The electrical characteristics of the motors available were utilised in the choice; (2) the type of service (motor drive without vibration or end thrust) called for a simple wooden foundation, and this was made adjustable; (3) a differentiation of the sources of heat made possible the elimination of one, the mechanical; (4) the motor was operated at a large overload by getting away the heat, (*a*) by air cooling and (*b*) by water cooling, and in the latter the large latent heat of evaporation was utilised in place of the small sensible heat; (5) the whole plant was set up as if for a laboratory test, a log was kept, and the data used to produce the best operation; (6) using all the information available it became possible to predict accurately the possibilities of the plant, then to confirm the prediction by actual results.

Conclusions.—In general two conclusions can be drawn from the case: (1) An impulse turbine, since it is not designed to withstand all the stresses to which it may be subjected either by design or accident, must be well protected by safety devices, and the same care must be given these devices as is bestowed upon boiler safety valves, including routine lifting by hand and steam; (2) were the wiring of ships installed similar to that ashore where by means of a three-wire system 110 volts can be had across two wires for lighting and 220 volts across two others for power, and were the appliances made to conform closely to a commercial standard, then the resources of the whole country would form a reserve from which to draw equipment in times of stress.

AMERICAN SHIPBUILDING.—The Emergency Fleet Corporation, Washington, has issued the list of shipbuilders now engaged on work for the United States Government, with addresses of business offices and location of shipyards. The list is published in *The Iron Age*, New York, and contains 31 builders of steel vessels, 69 builders of wood vessels, 5 builders of composite vessels, 1 builder of concrete vessels, and 27 yards building requisitioned ships.

LAXTON'S BUILDERS' PRICE BOOK.—This price book for the current year is the one hundred and first edition. It is published by Kelly's Directories, Limited, 182 to 184, High Holborn, W.C. 1, at the price of 4*s*. It opens with a most complete index which occupies 50 pages, then follow a list of specialities with name and address of manufacturers which occupies 40 pages, and the price book proper covering every item used and every profession employed in the building trade, and an alphabetical index to shipping marks or brands on sawn, planed and hewn wood, usually imported into Great Britain. The book contains about 73,000 prices, which are based upon the prime cost price of material and labour in November. All prices continue to advance, and many articles are unobtainable; the book, nevertheless, will prove as did the former editions, a most useful guide, and congratulations are due to the publishers for having succeeded in bringing it out in the present difficult times.

FUEL OIL FROM HOME SOURCES.—The Minister for Munitions, in agreement with the Secretary of State for the Colonies and the Petroleum Executive, has appointed the following Committee to inquire into certain matters relating to the production of fuel oil from home sources:—The Marquess of Crewe, K.G. (chairman), Colonel A. Stirling, M.P., Major Godfrey Collins, M.P., Engineer Vice-Admiral G. G. Goodwin, C.B. (Engineer-in-Chief of the Navy), Sir Richard Redmayne (representing the Controller of Coal Mines), Sir Lionel Phillips, Bart. (representing the Ministry of Munitions), Secretary: Mr. G. C. Smallwood (Ministry of Munitions). The following are the terms of reference:—"To consider the report which has been rendered by the Petroleum Research Department on the production of fuel oil from home sources, and to advise to what extent and within what time it should be possible under present conditions to carry out the proposals made in this report; and to consider the steps which have been taken by the Ministry of Munitions in this connection."

NATIONAL SALVAGE.—Conferences between the recently established National Salvage Board and representatives of metropolitan and extra metropolitan local authorities were held at the Local Government Board on March 20, 22 and 27. Mr. David Currie, Director-General of National Salvage, and Mr. I. G. Gibbon, the representative of the Local Government Board on the National Salvage Council, acted as chairmen of the conferences, which were held with a view of encouraging municipal effort in the recovery of usable materials from refuse, and to discuss the difficulties which had surrounded these efforts up to the present. Mr. Currie made a short opening statement in which he invited the co-operation of the London municipalities in this work of urgent national importance, and explained that the object of calling the conference was to afford an opportunity for discussing the lines on which salvage efforts could best be dealt with, and the methods which were likely to produce the quickest and most beneficial results. In considering such questions the council were desirous of utilising to the fullest the special knowledge and experience of municipal officials and engineers. He also stated that the council were securing a staff of technical advisers chosen from amongst those who had practical experience on the subject of waste collection and utilisation, and the services of these technical advisers would be at the disposal of any local authority desiring advice or help. As regards the disposal of products, he recommended that the existing trade channels should be utilised as far as possible. The council would do all they could to indicate markets and other methods of disposal.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Gannister Discovered.—Great headway is being made with the sinking of a shaft at Millhouses Wood, a picturesque spot in the Sheffield suburbs, for the working of a gannister bed, which has been discovered in an area, which is also reported to be coal-bearing. It is interesting to note that the arrangements are nearly complete at the brick works, near Millhouses, taken over by Messrs. Webster and Co., with a view to producing refractories in the finished state. Messrs. Webster and Co. control the quarries at Dore, where excellent gannister was discovered quite by chance in the earlier days of the war. The Sheffield steel trade has benefited considerably by this discovery.

Work Resumed.—Most of the works where a holiday was possible at Easter, resumed activity on Tuesday last week. In nearly every case where operations were suspended advantage was taken of the period to give attention to plant which has been ceaselessly worked under great pressure during a considerable spell, and with necessary overhauling of gear completed, and the workers refreshed after their seasonable respite, everything became in a state of preparedness for brisk business. In a smaller number of cases in works which had also been undergoing plant-repair, operations were left in abeyance until Monday this week to facilitate stock-taking.

The United Steel Companies.—In commercial circles one continually hears references to the new steel combine, which amalgamated steel interests of a far-reaching significance. Public attention is being called anew to the linking up of the great concerns which the United Steel Companies embody, by rumours which have gained currency that the combine has not yet reached its limit of expansion. The suggestion has been made that it may possibly involve new areas as widely separated as Frodingham and the Cumberland town, which, respectively, mark its eastern and western geographical boundaries. But even though there be no foundation for these rumours, one thing is certain, namely, that the United Steel Companies would seem to have a very promising future. The capital of over 10 millions sterling included 2,500,000*l.* debentures, and in the matter of directorate the combine is served by a set of gentlemen whose very association with the enterprise is one of the best auguries for success.

Iron and Steel.—It is not surprising to find that crucible steel makers have been making representations to the Government with a view to obtaining a wider opening for exports. As has been consistently pointed out in these notes during the past few weeks, the total home demands for crucible steel have fallen much below the productive capacity of the trade, and with so many orders existing abroad, to which access is only prevented by the restrictions on exports, it was generally felt that if the position were indicated to the authorities they would be able to come to the assistance of the makers. The success which has attended these representations, however, is only small, the reason presumably being that the demands more closely concerned with the prosecution of the war so fully claim available shipping that there is very little chance at the moment of opening wider the outlet for purely commercial exports. The steel trade generally is in a curious state. The briskness in the tool steel section declines more each succeeding week. The makers are not being asked for greater supplies than they can comfortably cope with, and the position is not calculated to be improved by the return to the district of considerable quantites of high-speed and other light steel, which had been despatched for transport to Russia. This is still another of the, perhaps, minor disadvantages—which in this case, will not be without inconvenience and probably loss to the original consignor—which have followed in the wake of the Russian debacle. In many cases electric furnaces are being turned to the manufacture of alloy steels for aircraft and automobile construction. Acid steel makers are being kept busy. The railway wagon scarcity continues, with the result that the supplies of forge and foundry pig remain unsatisfactory.

South Yorkshire Coal Trade.—Perhaps the most outstanding feature in the coal business is the high demand for house coal. It shows absolutely no sign of decline. The Easter holiday in the pits is interfering with business. During the stoppage large numbers of private wagons arrived at the collieries for loading, and a little time must elapse before these can be dealt with, with the consequence that there will be delay in getting consignments into railway and colliery wagons. Supplies for disposal in open market are small. Steam coal demands are heavy both for home and export, and slack is being persistently asked for. Makers are being pressed for blast furnace coke. Prices at the pit are as follow:—Best branch hand-picked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.* per ton.

HANDBOOK OF AUTOMOBILES, 1918.—This handbook is published by the National Automobile Chamber of Commerce, Incorporated, 7, East 42D-street, New York. It gives illustrations and the principal features, including prices, of the motor cars and lorries made by the leading manufacturers in the United States who are members of the National Automobile Chamber of Commerce.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—In the steel trade business continues to run on exceptional lines. Outputs are being maintained at the highest possible level and, as priority claims dominate the rolling of all classes of steel and all material classified according to control, supplies are always available for those engaged on Government contracts, with due regard to the importance of the work on hand, while little can be obtained by other customers. Meantime munitions are in heavy demand, and steelmakers are putting forth a great effort to keep the supply abreast of the demand. Finished steel of every description is also much in request. The production of heavy steel plates and angles, sections and other constructional material for the shipyards has been exceptionally well maintained, with the result that the Clyde yards have been able to bear a most creditable share of the increased output of shipping during the month of March. If things continue as they now are the expectation is that a considerable development may be looked for shortly.

Malleable Iron Trade.—Despite great activity in the malleable iron trade makers find much difficulty in turning out a sufficiency of material in response to the demands of consumers whose work is entirely of national importance, and the recent extension of plant has not availed entirely to obviate this. Sections of all kinds are in exceptional demand, but that for small rounds tops the list, and prices are pretty much a matter of arrangement. With the output barely adequate to meet the needs of consumers it is obvious that export must stand aside, even were shipping facilities much more plentiful than they are.

Scotch Pig-Iron Trade.—The prevailing scarcity of all grades of pig-iron is the predominant feature in the industry at the present time, and no stocks, can be laid up. Home requirements speedily absorb the entire output, everything produced going direct from the smelting furnace to the steel and iron works employed on Government contracts. Under existing circumstances, of course, little export is being put through, there being actually little to spare.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Some improvement in facilities for transport is reported, more trucks coming forward, but the shortage of wagons is still felt. The additional supply, however, promises to enable much heavier deliveries of Cleveland pig to home consumers, and the change is very welcome. Makers of Cleveland pig have rather large stocks, accumulated April allocations are issued freely, but some pig-iron producers are reluctant to enter into contracts they do not yet see prospects of fulfilling. Export transactions continue on only a very limited scale, but shippers are not without hope that improvement in foreign trade is at hand. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge are all put at 95*s.*; and No. 1 is 99*s.*; whilst for shipment to France and Italy, No. 3 and the lower qualities are quoted 114*s*; and No. 1 is 119*s*.

Hematite Iron.—Better accounts are given of the East Coast hematite branch of trade, the stringency having been relieved by increased output of basic iron, which is being more extensively taken up for steel-making. All home essential needs are now being adequately and regularly dealt with, and rather more hematite is available for disposal abroad. Mixed Nos. are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Blastfurnacemen's Wages Reduced.—The average net selling price (including subsidy) of No. 3 Cleveland pig-iron for the first quarter of the year has been certified at 108*s.* 3·59*d.* per ton, as compared with 109*s.* 3·03*d.* for the previous three months, a reduction in price of 11·44*d.* per ton, which means a reduction in blast furnacemen's wages of 1·25 per cent, bringing wages from 96·50 per cent. above the standard to 95·25 per cent. above the standard. The reduction takes effect from the 7th inst.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel are kept very fully employed on Government contracts, and work for the shipyards. Production of shipbuilding material is on a huge, and still growing scale. To home customers, common iron bars are 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; double best bars, 14*l.* 12*s.* 6*d*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 15*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*—all f.o.t. at works and distribution is strictly controlled.

Manufactured Iron Workers' Wages.—Messrs. Price, Waterhouse & Co., the accountants to the Board of Conciliation and Arbitration for the manufactured iron and steel trade of the North of England, report that for the first two months of the year, the average net selling price of manufactured iron was 13*l.* 16*s.* 7·64*d.*, as against 13*l.* 14*s.* 5·70*d.* for the last two months of last year. The increase in the average selling price does not affect wages under the sliding scale arrangement, but the advance of 1*s.* per ton in the puddling rate, and 10 per cent. on other forge and mill wages, which took effect from January 28th, under sanction from the Ministry of Munitions, in respect of the subsidy, will continue to be paid.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Following the holidays, the depletion in the stocks of coal by the end of last week was estimated at over 80 per cent. In many cases it was ascertained that less than one-fifth of the colliery wagons were loaded. The outputs at the collieries naturally increased this week, but all classes of coal continue relatively scarce, while the shortage of best, large and small steams is more marked than that of other descriptions. Coke and patent fuel are in as active demand as coal, and there is no doubt that much more patent fuel could be placed if the labour were available to produce it. All the factories are reporting a shortage of men. The pitwood position is unaltered, but there are prospects of an increased supply from home-grown sources.

Newport.—All the pits in the Eastern or Western Valleys of Monmouthshire continue to work full time this week. There is a relative shortage of supply for most descriptions, both of large and of small coal, but this change from the normal condition of congestion is probably only temporary, for outputs will soon be restored to their old levels.

Miners for the Army.—Some concern is still felt as to how much mischief is being done in the coalfield by the extremists in connection with recruiting of miners for the army. A conference of delegates is convened to be held at Cardiff to-morrow by the South Wales Miners' Federation to "consider and decide whether the Federation is to exercise any form of supervision over the workmen called up for military service under the comb-out." The great majority of the members of the Executive Committee are strongly in favour of the machinery of the Miners' Federation being used to assist the recruiting authorities, and will submit a recommendation to the conference to this effect. In view, however, of the activities of the extremists at the local miners' lodges it is very doubtful whether the delegates will accept this recommendation, and the outcome is awaited by a good deal of anxiety by the more responsible of the men's leaders.

Suspension of Coal Allocation Scheme.—Considerable interest has centred this week in the unexpected suspension of the scheme for the allocation of orders, which, it will be remembered, was adopted with the view of mitigating the evils of short-time working at some collieries by a more equal distribution of trade. This scheme was to have come into operation on Monday. A week or so ago, the collieries received from the South Wales Coal and Coke Supplies Committee the quantities they were to produce for the month beginning on April 8. These quantities ranged from 70 per cent. to 80 per cent. of the collieries' outputs in the first quarter of 1917. There was some dissatisfaction at the respective allocations, and generally doubts were entertained as to the practicability of any system of allocation under such exceptionally abnormal conditions as those which now prevail in the South Wales coal trade. The need, however, for a more equal distribution of orders was felt, and salesmen were prepared to give a fair trial to the experiment of a percentage restriction on outputs. Consequent largely upon the holidays and other factors there has been a depletion in stocks down to the point of almost actual shortage, especially in some grades of coal. The authorities, therefore, came to the conclusion that in these altered circumstances production should be liberated from any artificial restraint, and, at their suggestion, notices were received by the colliery companies on Monday morning informing them that the operation of the allocation scheme was postponed for a week, and that consequently, they should go on producing to the fullest practicable extent. This development has given rise to the question as to whether it is worth while proceeding any further with the scheme. At any rate, the whole scheme is being reconsidered, and during this week colliery companies, in their individual capacities, are submitting their respective cases to the Coal and Coke Supplies Committee, and the point is to be considered whether the scheme should be continued after the expiration of the present period of suspension or amended in the light of the experience of the past week.

TUNGSTENITE, A TUNGSTEN SULPHIDE.—Although the chemist knows two tungsten sulphides, WS and WS_2, corresponding in their compositions to the oxides, no natural tungsten sulphides was known until last year, when a very complex tungsten ore, apparently the sulphide WS_2 was discovered in the Emma mine, situated in the Little Cottonwood district, 25 miles south-east of Salt Lake City, Utah. The mine used to be rich in lead-silver ores, but had hardly been worked for forty years. The mineral in question resembled graphite in appearance, forming lead-grey feathery flakes, opaque, of metallic lustre, sufficiently soft to mark paper, but very heavy, the density of the pure substance being probably 7·4. B. C. Wells and B. S. Butler, of the United States Geological Survey, who described the occurrence in the Journal of the Washington Academy of Science, of December last, experienced great difficulty in the analyses on account of the complex character of the ore. The specimens contained about 45 per cent. of tungsten, 29 per cent. of sulphur, 9 per cent. of iron, and 4 per cent. of lead, together with 1 per cent. or less each of arsenic, antimony, zinc, manganese, copper, silver, nickel, &c. Assuming the tungsten to be present as WS_2, the ore contained 61·5 per cent. of this sulphide, which would be analogous to molybdenite MoS_2. The tungsten sulphide is not attacked by hydrochloric and nitric acid, but is decomposed by aqua regia; it is not oxidised by roasting in air, but burns in oxygen.

NOTICES OF MEETINGS.

THE CERAMIC SOCIETY.—Saturday, April 13, at 7 p.m. in the Central Schools of Science and Technology, Stoke-on-Trent, when the following papers will be read:—"Sudanese Pottery," by Mr. F. Stirk, of Omdurman (to be read by Mr. W. Emery); "The Bonding of Easy-Fired Ware," by Mr. B. Moore.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, April 13, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion:—"The Flow of Water in Syphons," by Mr. Mark Halliday, B.Sc. [Trans. Inst. M.E., 1917, vol. liv, pages 107 and 335]; "Notes on the Uniflow Steam Engine," by Mr. G. G. T. Poole [Trans. Inst. M.E., 1917, vol. liv, page 339]; "A System of Storing and Filling Small Coal, with Remarks upon the Prevention of Spontaneous Heating in Coal Heaps," by Mr. John Morison [Trans. Inst. M.E., 1918, vol. lv, page 76]: "The Strength of Pit-props," by Mr. Fred. L. Booth [Trans. Inst. M.E., 1918, vol. lv, page 87]; The following paper will be read or taken as read:—"Systems of Conveyor Face Working," by Mr. F. C. Lee, M.A. (Chin.), B.Sc.

THE ROYAL SOCIETY OF ARTS.—Monday, April 15, 4.30 p.m. (Cantor Lecture): James Young, O.B.E., F.C.S., "Military Explosives of To-day" (Lecture II). Wednesday, April 17, 4.30 p.m. (Ordinary Meeting): Frank Stuart Courtney, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." Thursday, April 18, 4.30 p.m. (Indian Section): Alfred Dickinson, M.Inst.C.E., "Water Power in India." The Right Hon. Lord Lamington, G.C.M.G., G.C.I.E., will preside.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, April 16, at 5 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, London, a paper on "Light and Vision: the Physiology of the Retina," will be read by Professor W. M. Bayliss, F.R.S.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Tuesday, April 16, at 7 p.m., in the Mining Institute, Neville Hall, Newcastle-on-Tyne (not the Literary and Philosophical Society), discussion on the following paper will be resumed:—"Ferro-Concrete Ships," by Mr. T. J. Gueritte.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, April 16, at 7.15 p.m., in the Mining Institute, Newcastle, when a paper on "Reducing Values" will be read by Mr. T. W. Stewart, to be followed by a discussion on the "Analogies of Electrical and Mechanical Engineers."

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday evening, April 16, at 8 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. The following paper will be read: "Relation between Viscosity and the Chemical Constitution of Lubricating Oils," by Mr. A. E. Dunstan, D.Sc., F.I.C., F.C.S., and Mr. F. B. Thole, D.Sc., F.C.S. The chair will be taken by the President, Mr. Charles Greenway.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, April 17, at 5 p.m., at 70, Victoria Street, Westminster. Papers to be read:—(1) "The Variations of Underground Water-Level near a Tidal River," by Mr. E. G. Bilham, B.Sc., F.R.Met.Soc. (2) "Suggestions as to the Conditions Precedent to the Occurrence of Summer Thunderstorms, with special reference to that of June 14, 1914." by Mr. James Fairgrieve, M.A., F.R.G.S.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, April 17, at 7 p.m., at the University, Edmund-street, when Mr. E. C. McKinnon, A.M.I.E.E., will read his paper entitled "Large Batteries for Power Purposes." It is found that it will be impossible to hold the Annual Meeting as originally intended on April 17, 1918.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 18, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "Overseas Distribution of Engineering Appliances," by Mr. L. Andrews, Member.

ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, April 19, at 5.30 p.m., a Discourse will be delivered by Major G. I. Taylor. The subject will be "The Use of Soap Films in Engineering." Afternoon Lectures at 3 p.m.:—Tuesday, April 16: No Lecture. Thursday, April 18: Lieutenant-Colonel C. S. Myers, R.A.M.C., M.D., D.Sc., F.R.S., on "Present-Day Applications of Experimental Psychology" (Lecture II). Saturday, April 20: Professor E. H. Barton, D.Sc., F.R.S., on "Musical Instruments Scientifically Considered" (Lecture II).

ELECTRICITY SUPPLY FROM PUBLIC MAINS.—In future, all applications to the Ministry of Munitions for Priority Certificates to enable motors and other electrical plant (requiring a supply of current from the public mains) to be purchased, should be accompanied by a certificate from the Chief Engineer or Manager of the Public Service Undertaking concerned, stating:—(1) That adequate generating plant capacity is or is not available. (2) That no additional cost or material is involved in connecting the premises to the mains (including sub-station equipment, if any); or (3) Where expense is involved, the material and apparatus to be provided and the cost thereof, and whether lead-covered cable is necessary or not. Where lead-covered cable is deemed necessary, the voltage of the current transmitted should be stated. Applicants should, whenever possible, also obtain the written support of the Government Department interested in their manufactures, and forward a copy of same. The purpose of the above procedure is to reduce the demand for current—other than that used for urgent war purposes—supplied by the Public Service Undertakings, and the time occupied in making inquiries.

EMERGENCY REPAIRS ON A UNITED STATES BATTLESHIP.

(*For Description, see Page* 397.)

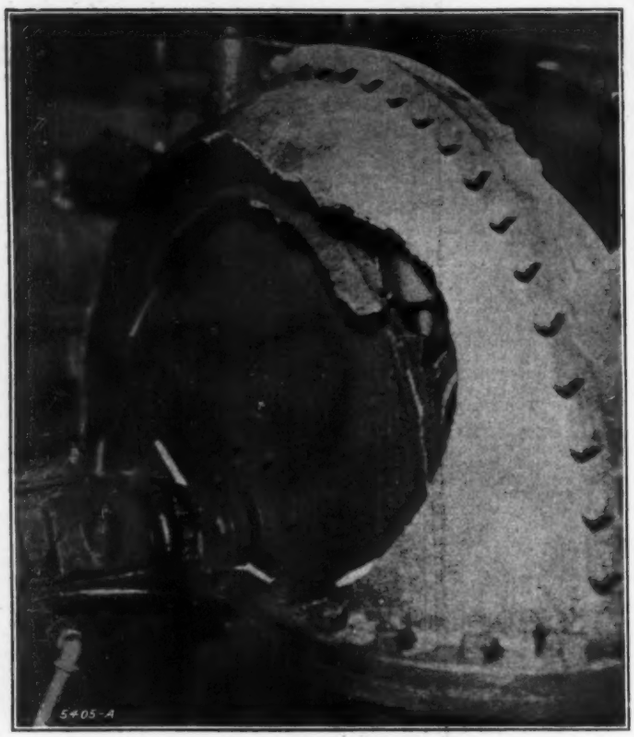


Fig. 3.

Fig. 4.

Figs. 3 and 4. End of Turbine after Explosion.

Fig. 5.

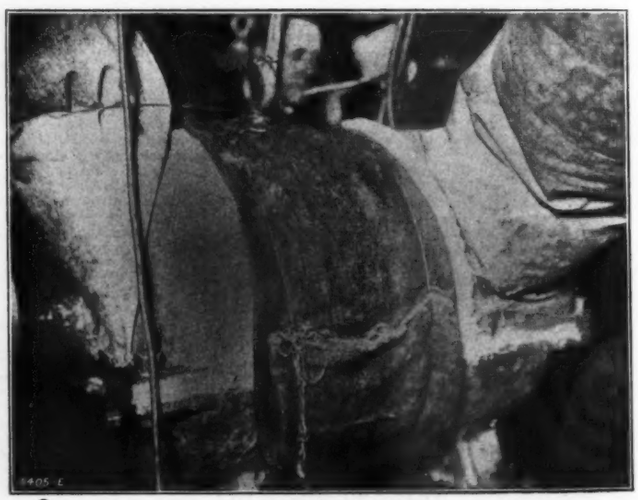


Fig. 6.

Figs. 5 and 6. Air Cooling Arrangements for Electric Motor.

Building Bricks.—The Minister of Munitions has issued an order dealing with the trade in building bricks, all applications concerning which should be made to the Controller of Building Bricks, Ministry of Munitions, Whitehall Place, London, S.W.1, and marked "Building Bricks Permit."

Aluminium Crystals and X-Rays.—The method of Debye and Scherrer, to which we have referred on other occasions, has the advantage over the methods of Lane and of Bragg that the Röntgen ray examination by this method does not need properly developed crystals, which may not be available in sufficient size, but can be performed with microcrystals or crystalline powders. Aluminium is hardly known in crystals, though Deville spoke of octahedrons in his early researches. Compressing crystalline particles of aluminium, not exceeding 0·01 mm. in length, into cylindrical rods, 1 mm. in diameter, and testing them by X-rays, P. Scherrer (*Physikalische Zeitschrift*, January 15, 1918, pages 23 to 27) finds by X-ray examination that the aluminium atoms are arranged in a face-centred lattice, the elementary cube having a length of $4{\cdot}07 \times 10^{-8}$ cm. The metals copper, silver, gold, lead also form elementary cubes of very similar dimensions, the lengths being 3·61, 4·06, 4·07, $4{\cdot}91 \times 10^{-8}$ cm. respectively. These four metals and aluminium should hence be isomorphous in the ordinary sense and capable of forming mixed crystals (within limits), that is to say the mixed crystals will not represent a continuous series, in which the two metals of a binary compound may be present in any proportions, but there will be gaps in the series. In the case of aluminium and gold, whose elementary cubes seem to have exactly the same dimension, $4{\cdot}07 \times 10^{-8}$, the gaps are very conspicuous; some of these gaps would be taken up by chemical compounds between the two elements, and according to Tammann gold and aluminium seem to be able to form five compounds with proportions Au : Al as 1 : 1, 2 : 1, 4 : 1, 4 : 2, 5 : 2.

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With Four One-Page Plates of the SCIOTOVILLE BRIDGE OVER THE OHIO RIVER.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 399.

ENGINEERING.

FRIDAY, APRIL 12, 1918.

COMBINATION IN THE STEEL TRADES.

IN view of the probable extension and development of trade organisations and combinations a committee has been appointed by the Minister of Reconstruction to consider and report what action, if any, may be necessary to safeguard the public interest. It is to be hoped that neither popular nor Parliamentary prejudice against what are called "trusts" will be permitted to stand in the way of efficient combination among our manufacturers, engineers and merchants, for it is clear to all unbiased minds that combination, or organisation, will be necessary if we are successfully to meet the competition of certain highly organised and State subsidised rivals. Without a doubt, individual initiative, or enterprise, was one of the chief factors in our progress in the nineteenth century; but the same quality is not sufficient to maintain our position in the twentieth. In modern international competitive commerce organisation is the very mainspring of success. Some of the committees appointed in 1916 to consider questions of trade after the war have had the courage to recommend the formation of strong associations of manufactures. The committee that has been dealing with the electrical trades has reported strongly in favour of combination. The Engineering Trades Committee recommends co-operative selling companies, or combines. The Iron and Steel Committee favours concerted action by manufacturers in the establishment of selling organisations, divided into groups for the various products. It is recommended that legislation should be introduced, if necessary, to give legal sanction or remove legal objections to such associations. Meetings under the auspices of the Board of Trade should, in the committee's opinion, be called forthwith.

It is certain that if we are to win what is called the coming trade war we must have, as indispensable conditions of success, industrial efficiency and commercial organisation—the highest possible output, consistent with quality of product, in our workshops, and the best possible organised selling campaign in the world's markets. We seem in a fair way to secure again, as we did in the last century, a standard of manufacturing and engineering efficiency unsurpassed, if not unequalled, by any of our competitors. Under the stimulus of war our industries are being modernised and specialised, and our workmen are speeding up. But our prospects in the matter of trade organisation are hardly so promising. Many of our manufacturers are still very conservative, or individualistic; our politicians rail against combines, or trusts; and even our trade unionists and Socialists oppose organisation among capitalists. Yet nothing is more certain than that efficient organisation, or combination, or co-operation, will be necessary if we are to secure sufficient trade after the war adequately to employ our works and workers. The successes of our various foreign rivals in certain trades before the war—of the Germans in steel, for instance, of the Americans in motor cars, and of the Danes in the butter trade—were due almost entirely to superior organisation, compared with our methods. If we are to regain and retain for our country the leading position in the world's iron and steel markets against highly-organised German competition, we must have the closest organisation among ourselves. There is no other way to success.

During the thirty years before the war the world's consumption of iron and steel and engineering products, measured in tonnage of pig-iron, increased, in round figures, from 20,000,000 tons to 70,000,000 tons a year. That was practically a *per capita* increase in consumption of 150 per cent. But in that period our British *per capita* output did not increase by even 1 per cent. Relatively to the world's population all the increased trade went to our competitors. The Germans increased their *per capita* production by nearly 200 per cent., and the Americans (United States) theirs by 300 per cent. In round figures, the United States output increased from about 5,000,000 tons a year to 30,000,000 tons; the German output from 3,000,000 tons to 18,000,000 tons; and the British output only from about 8,000,000 tons to 9,000,000 tons. In the exportation trade the figures were still more strikingly against us. In only fifteen years the highly syndicated Germans increased their iron and steel exports from less than 800,000 tons to a rate of 7,000,000 tons a year for the last six months before the war. In the same period our exports only increased from about 3,300,000 tons to a rate of 5,000,000 tons a year on the eve of the war. Yet our natural resources, our geographical situation, our shipping facilities, and our economic position, by virtue of our huge Colonies, to name only one point, were all alike superior to those of our competitors. But the Germans were strongly organised for trade purposes, whilst we were poorly organised. That is the real explanation of these figures. The lesson is plain and unmistakable; we must organise with almost military thoroughness, or we may be worse beaten in the future, for the Germans are actually strengthening their syndicates, under State support, and other rivals are making most ambitious commercial plans. One of the most notable features in the balance sheets of German steel, iron and coal companies, during the past few months, has been the drastic writing down of the value of plant. Before the war the Aktien-Elektricitats Gesellschaft only credited itself with one mark on account of its numerous and immense assemblage of tools. Now this valuation is becoming quite common, and there are a dozen or so of great firms which have practically wiped out their expenditure on plant by taking sufficient sums from their immense war profits. It is easy to see that in the coming competition they will occupy a very favourable position, since their standing charges will be extraordinarily light. In addition they have credited large sums to their benevolent and welfare schemes, so that these will make much smaller demands on them in the future. In many ways they are "lightening the ship" in readiness for the time when the seas will again be free to their navigation and commerce.

In many trades and markets in the past we have been practically at the mercy of foreign trusts and syndicates. We have been undersold and beaten by superior organisation. And that will surely happen again if we fail to organise on our side. We must drop old theories and prejudices and grasp up-to-date facts. To employ all our plants and labour after the war we shall need a much larger export business than ever we had in the past. To obtain this we must have the most efficient methods in our foreign trading. Reckoned in terms of steel, our productive capacity is likely to be at least 50 per cent. greater than it was before the war. We shall need an export trade of something like 7,000,000 tons or 8,000,000 tons of iron and steel a year to keep ourselves fully employed. There will certainly be a big world demand for iron and steel; but it is equally certain that there will be some big and powerful—some highly organised—competitors bidding for the business. In this

military war we have to fight or perish. In the coming commercial contest we shall have to organise or perish. The benefits of organisation, or combination, in the iron and steel trades were admirably set out before the committee by Sir W. B. Peat, who was one of the chief witnesses, as follows: (1) Influence in limiting speculation and steadying prices; (2) securing information regarding the world's requirements, which is too great an expense for any individual firm; (3) the taking of larger contracts than one firm would be prepared to risk; and (4) that technical developments, scientific research and investigation of raw material supplies can be undertaken better by co-operation.

THE RUSSIAN PETROLEUM INDUSTRY.

HAVING in recent meetings reviewed the prospects of petroleum industries and cognate industries in the United Kingdom and the Empire, and also discussed Rumanian petroleum, the Institution of Petroleum Technologists, on March 19, listened to a paper on "The Russian Petroleum Industry and its Prospects." The paper was by Mr. D. Ghambashidze, honorary secretary of the Russo-British Chamber of Commerce in London, and dealt more with general economic and statistical features than with the technical side of the problems. But in the development of a petroleum industry manifold commercial, technical and other problems are peculiarly interlocked.

In his review, Mr. Ghambashidze referred first to the smaller petroleum fields, some of which remain in the experimental stage though great hopes were placed upon them years before the war. They are all situated either in districts bordering upon the Caspian Sea, which has no outlet, though it covers an area larger than that of the British Isles, or on the slopes of the Caucasus Mountains crossing, in a length of more than 600 miles, the land between the Caspian and the Black Sea, which has only one outlet through the Bosphorus and the Dardanelles. The oil fields in Transcaspia mentioned by Mr. Ghambashidze were Tcheleken Island, in Krasnovodok Bay (on the eastern shore of the Caspian, opposite Baku), and at Tchikishliar and Naphtha Hill, on the Transcaspian Railway; the Tcheleken oil was rich in petroleum and in heavy tar, he stated. The Fergana field near Vanovsk, on the Central Asian railway, belonged to Nobel Brothers, and the 10 wells of 1915 produced between 1,000,000 poods and 2,000,000 poods annually (1 pood = 36 lb.). The oil production from the Ural Caspian (the River Ural flows into the Northern Caspian) at Dos Sor and Novobogatinsk, near Emba Bay, had amounted to nearly 17,000,000 poods in 1915; the oil contained a considerable percentage of sulphur, and the former district was unfavourable as to water; but the Djingi field (nearer the Volga), also developed by Nobel, attracted much attention. Of fields near the Black Sea, Mr. Ghambashidze mentioned Guri (near Batum), which caused a rush in 1911 and 1913, and the better-known fields of the district of the Kuban River, the delta of which separates the Sea of Azov from the Black Sea; this is on the north-western slope of the Caucasus. At Maikop a prolific gusher broke out suddenly in 1909, much oil was lost, pipe lines were laid to Einem railway station and the Tuapse port, and over 9,000,000 poods of oil were produced in 1912, but by 1914 the yield was down to 5,000,000, and in 1915 only 5 out of 66 companies, most British capital, survived. Other fields had been opened up at Anapa and Taman (on the Black Sea) in 1912. In the Grozni fields, on the northern slopes of the Caucasus, near the Vladikavkas railway, boring commenced in 1903; but though the wells went now down to 3,000 ft. and 4,000 ft., their output was diminishing; improved methods were applied, however, to prevent surface flooding of the wells and other troubles, and 385 out of 773 wells were in operation. The Grozni oil was especially suitable for benzene production, and since the closing of the Dardanelles enormous quantities of oil had accumulated in that district.

Passing to Baku—on Apsheron Peninsula, at the eastern extremity of the Caucasus on the Caspian—still the all-important centre of the Russian oil industry, Mr. Ghambashidze stated that before 1870 all oil had been dug by hand. Then American boring commenced; by 1887 the wells had increased in number to 216, many yielding up to 10,000 poods per day, but deep drilling without due exploitation of the upper strata had done much harm, until (since 1873), Robert Nobel's enterprise and technical genius led to a systematic development. By 1900, 1,710 wells were in operation, the number was 2,818 in 1899, down to 2,066 again in 1910, and had since fluctuated, being 2,541 in 1914; the subsequent falling-off in drilling operations was mainly due to the difficulty of obtaining tools and materials. The general production of Russian petroleum had been in million poods: 707.2 in 1901, going down to 453 in 1905, keeping between 500 and 600 since 1907, and reaching 603 million poods in 1916. The number of firms had fluctuated much less, being 185 in 1901 and 191 in 1911; 7 of these firms produced more than 20,000,000 poods of oil annually, 5 more than 10,000,000 poods, and 135 firms less than 2,000,000 poods. About 1912 the large and middle-size firms began to consolidate, and by 1913 the Shell group produced 11.8 per cent. of the total output, the General Russian Corporation 12.8 per cent., Nobel Brothers 14.2 per cent., and the remaining 165 firms 58.8 per cent. of the total. Thus the first three groups together produced 41 per cent. of the total and might united control both the production and the sale; there were contracts, but so far there was no appearance of a trust.

The output of the different Russian fields in 1915 (1916) was, in million poods: Baku, 451 (379); Grozni, 88 (102); Tcheleken, 3 (3); Maikop, 8 (3); Emba 17 (15); Fergana, 2 (2). The prices had always fluctuated a good deal; we give the average prices of crude oil in kopeks (100 kopeks = 1 rouble = 3*s.* nominally), in 1911, –12, –13, –14, –15, –16, –17: 20.6, 34.5, 42.7, 35.7, 41.2, 45.7, 68; the price of January, 1918, was 96 kopeks. In March, 1916, the Government fixed the price, but the legal maximum was not observed in practice.

Refining had first been resorted to in order to obtain illuminating oil from oil-sand called Kir; then oil was refined by means of sulphuric acid, and the lamp oil was brought nearer the standard of American kerosene, which it had not yet reached, however. Continuous distilleries were introduced in 1875 and improved by Nobel; by 1876 Baku had 140 distilleries, which became a nuisance and were restricted to the "Black Town." Nobel also built sulphuric acid works utilising Caucasian pyrites. Officially refineries were distinguished as to their three chief products: kerosene; benzene and goudron; lubricating masut. The kerosene refineries were originally more than twice as numerous than those of the other two classes, because the distillation residue was largely burnt. Of late the number of refineries (177 in 1893) had much decreased, and the numbers of factories making the chief products were in 1907, –10, –11, –12: kerosene 59, 43, 39, 10; lubricants, 17, 16, 14, 9; solar oil, 2, 3, 3, 1; benzene, 1, 2, 2, 3: residues, 6, 6, 5, 3; paraffin, 1, 1, 1, 2,; totals, 86, 71, 64, 28. Nearly all the oil produced in the Caucasus was refined in that region; the refineries in Nishni-Novgorod, Moscow, Petrograd, and Riga together distilled only about 12 million poods yearly. Of the 23,849,000 poods of products of the Baku refineries obtained in April, 1916, illuminating oils made up 5,875,000 poods, lubricants 980,550, solar oil 514,000, benzene 101,300, naphtha residues 13,585,000, paraffin 6,800, other products (gasoline, goudron, masut, &c.) 2,786,000 poods.

The transport question was one of the most important. It was again Nobel Brothers who started a pipe line to their factories, replacing transport by skins and barrels on carts and camels. There was then no railway from Baku to the Black Sea, though navigation on the Caspian and up the Volga was open for six months. When the railway Baku-Batum was built, Nobel introduced cistern wagons and laid pipe lines on difficult sections; the great pipe line, 8 in. diameter, from Batum (Black Sea) to Mikhailovo was opened in 1890, that from the latter place to Baku only in 1906, thus completing the 560 miles of pipe line across Transcaucasia. The line, which was not intended for crude oil, had 19 pumping stations, and a capacity of 60 millions poods per year, sufficient for its purpose; it cost 25 million roubles; since the closing of the Dardanelles the pipe line had partly been idle. Fleets of steamers (118 in 1912) and of sailing vessels (60 in 1912 against 140 in 1906) carried 5½ million and nearly 2 million poods of oil in 1912 across the Caspian. By 1916 the oil transport statistics were: by Transcaucasian railway, 2.5 million poods, to Batum 1 million; Valdikavkas railway, 0.5 millions, by sea to Astrakhan 44 million, &c., a total of 49.7 million poods. The Grozni oil went partly to Novorossisk (the Suchuk Kale of old maps) on the Black Sea for refining, while the residues were sent through pipes to Petrovsk on the Caspian; the Maikop oil was refined at Ekaterinodar and consumed locally.

As regards redistribution, the lecturer remarked that the home market was in need of oil for heating and lighting, and when since 1906 American competition diminished oil exports considerably, the home market absorbed the greater part of the production. In 1916 the Government worked out a plan for the distribution of the 60 million poods of illuminating oil all over the country. The shippings of fuel oils to Volga ports amounted in 1913, –14, –15 to 77, 75, 103 million poods, the increase in the last year being due to the scarcity of coal. Baku itself used from 10 per cent. to 15 per cent. of its crude oil as fuel, but the development of electric power and fuel-saving engines was diminishing that figure. That in the early years Baku petroleum mostly went abroad was due to transport difficulties and further to the fact that the Government fostered the export trade by an export premium of 4 per cent. Hence 100 huge tanks rose at Baku, and tin can and wooden case factories were started, Rothschild's factory alone making and filling 36,000 tons per day since 1892. But foreign competition already made itself strongly felt; the Government summoned a conference of petroleum industrials to Petrograd in 1893, and the firms of Nobel and of Rothschild on their behalf came to an agreement with the Standard Oil Company in February, 1894, to divide the world's market. The new Russian Union did well, exports increased, especially to Turkey, Egypt, Persia, India, China, Japan; but the smaller firms were dissatisfied, and by October, 1897, the Union was wound up. Yet the total exports from Baku alone amounted in 1913, –14, –15, –16, to 371, 322, 385, 409 million poods. In the general exports there was a decline, however, after 1905, notably to the west of Europe and further also to India, China, and Japan, which countries had absorbed 70 per cent. of the exports.

Oil imports from America, and later, in the nineties, from Galicia and Rumania, as well as the new oil industries of the Dutch Indies and Burmah, had weakened the Russian industry already since the 'sixties, when the first 100,000 poods of American petroleum appeared in Russia. When freight from New York to Kronstadt was 30 kopeks per pood the freight from Baku to Nishni-Novgorod was 25 kopeks, and financial conditions and Government interference hampered the Russian oil development. We reproduce Mr. Ghambashidze's figures for the oil production of the last years, though they can hardly be reliable; the figures are in million barrels of 42 gallons, for the years 1914, –15, –16, –17: United States 266, 281, 301, 342; Russia, 67, 68, 73, 70; Mexico, 21, 33, 40, 60; Dutch East Indies, 13, 12, 13, 14.5; Rumania, 12.7, 12, 10, 11; Galicia, 5, 4, 6.4, 5—we have rounded the figures off.

Labour troubles, the lecturer proceeded, had, owing to the heterogeneous mixture of nationalities—Russian, Caucasians, Persians, Tartars, Armenians, the last two making up more than half of the labourers—not assumed any serious aspect until the great strikes of 1903; then followed the Armenian-Tartar massacres of 1904, the revolution of 1905, and the general depression of the industry. In 1913, about 60,000 people were employed in the petroleum industry of the Caucasus, 45,000 of these being in the Baku district; 71 per cent. of the officials and men were housed, 22 per cent. were paid lodging money. An eight-hours' day at the wells and nine-hours' day in the shops were introduced in 1909, and other social improvements adopted, partly owing to trade unions. The Baku Petroleum Industrial Association dated from 1889 already; the funds of this very useful association were derived from payments per pood of crude oil produced,

and also from the sale of oil accidentally collecting on the roadways; the association looked after roads and lighting, and two hospitals and nine schools, with 57 branches, were maintained from these funds.

As regards State rights, land ownership and finances, the State had periodically granted concessions and worked the wells on its own account from 1821 till 1872. State concessions were then abolished, and the land passed, at once or at later periods, from the Crown to private owners, largely by auction. An excise duty was also introduced; it was 4 kopeks per vedro (2.7 gallons) of oil distilled for each day the still was in operation. Export premiums were afterwards granted, and lubricating oils and goudron released from excise. A distinction was then made between light and heavy kerosenes and kerosenes of flash points above and at 45 deg. C., the former paying 40 kopeks, the latter 30 kopeks, all other oils being free. Very low-flash oils had afterwards to be prohibited as dangerous, however, and the classification was altered. In 1906 an excise duty of 60 kopeks was put on all transparent oils, against the protests of Baku. In 1914 the Government resolved to accept duty in kind, instead of cash, under the stress of the war, and in 1917 a duty of 5 kopeks was enacted from crude oil which had so far been quite free. Foreign capital had, since 1872, when Nobel founded his company on the extinction of the concession system, been a very essential factor in the development of the Russian oil industry. While the Russian companies only increased their joint capital to 13,000,000 roubles by 1915, the old essentially foreign companies had raised their investments to 80,000,000 roubles, and the new companies relied mainly on foreign money. British investments had from 1898 to 1903 increased to 86,000,000 roubles, and the new fields at Grozni and elsewhere were almost entirely controlled by British and French capital. Concluding, Mr. Ghambashidze expressed the hope that foreign capitalists would continue to interest themselves in Russian petroleum. The question of a State monopoly had lately been brought forward again; but the State could rely upon larger sources of income by giving full swing to private initiative than by favouring monopolies.

As pioneer of the petroleum industry Baku has had a long and very severe struggle. The world has much advanced since, and receded as well. Yet the Baku experience may prove instructive. There remain vast tracks of unexplored lands which the discovery of natural oil would find as unprepared almost for the development of an industry as Baku was a few generations ago.

THE SILVANUS THOMPSON MEMORIAL LECTURE.

THE Silvanus Thompson memorial lectures of the Röntgen Society were auspiciously inaugurated on Tuesday, April 9, by Sir Ernest Rutherford. The remarkable versatility of Thompson, as a scientist, artist and man, left the lecturer the choice of a large range of subjects for his address. Optics, electricity, magnetism, acoustics, education, music, painting, literature, economics, interested the experimental investigator and the teacher, as well as the man Thompson, who approached every task with a warm heart and excelled in many domains. But the Röntgen Society was probably pleased that their lecturer,—though "he had cut his first tooth over Thompson's dynamo-electric machinery"—selected their own and his own field of study, and that he dwelt in particular on the revolutionary changes in attitude that scientific thought in general has undergone since 1895, when, as the President of the Society, Dr. G. W. C. Kaye, put it, Röntgen discovered the X-rays by a "fortunate accident." That discovery stimulated a group of enthusiasts over here to form a society, and casting round for a leader, they offered the presidency to Professor S. P. Thompson, who delivered his brilliant inaugural address on November 6, 1897. Thompson, Sir Ernest afterwards mentioned in his introduction, had experimented on Röntgen rays as soon as he heard of the discovery, and obtained an X-ray photograph that same evening. When Thompson's sudden death, in June, 1916, shocked the whole scientific world and many friends, the Röntgen Society decided to endow a Thompson memorial lecture, and to attach a Thompson medal to it. The first medal was presented by Captain Kaye to Sir Ernest Rutherford at the end of the lecture.

The "fortunate accident," many will remember, occurred in a period of intense activity in the exploration of the electric discharge through gases, and progress was first made in this particular direction and in the study of what the new rays rendered visible for the first time. Though bold speculations were plentiful from the beginning, however, it was hardly foreseen that the discovery would revolutionise our ideas on electricity and on matter, and that from a period of rash hypothesis there would soon emerge novel fundamental facts, which were no longer questioned. How this took place, Sir Ernest exposed in a rapid review. It was refreshing to hear him speak of the chaotic conditions of times not so long past, when the bewildered engineer abandoned the hope of understanding the novel notions which seemed to shatter the old-established apparently simple, atomic theory, and the permanent, immutable atom, which nobody yet had hoped ever to see, whilst he was now told that he might actually watch its explosion.

As regards the elucidation of the nature of the X-rays, Sir Ernest pointed out, progress was first slow. But in 1896 already, Sir J. J. Thomson explained the nature of the ionisation and conductivity of gases; Townsend discovered that fresh ions resulted from collisions, and O. W. Richardson and others showed that ions were liberated from hot substances—all purely theoretical researches, apparently, which yet had found most useful application in the wave detectors and the current rectifiers and amplifiers of radiotelegraphy and radiotelephony; they had, in fact, rendered radiotelephony across the Atlantic possible. That the X-rays themselves were connected with kathode rays had seemed certain from the outset. But Crookes' previously-made suggestion that kathode rays constituted a new fourth state of matter, did not find real support until Kaufmann showed that the small flying particles were really electricity in motion, that their mass was entirely electric, and that a kathode ray was a disembodied atom of electricity. The interpretation of the Zeeman effect was a proof of the fact that the electron was a definite constituent of the atom. It was unnecessary, Sir Ernest continued, to emphasise the importance of the varied researches of J. J. Thomson on the part played by the electron in the constitution of the atom.

The discovery of radioactivity was another happy consequence of the discovery of the X-rays. Many people had thought that the phosphorescence of discharge bulbs was connected with the rays, and that phosphorescent bodies should emit a penetrating radiation; the assumption had been wrong, but its investigation led Henri Becquerel to the discovery of the peculiar radiation from uranium. When the Curies had separated polonium and radium, 30 new elements, some subsisting for minutes, some having extraordinary longevities, in most cases not isolated in sufficient quantity to be seen, were added to the number of elements, though unfortunately on Mendeleieff's table no places seemed to be left for the newcomers. That was the chaotic period (to which we already alluded) which Sir Ernest himself ended by developing his law of disintegration. At present the sequence of the chief changes and the main scheme of transformation were understood, he remarked, and it was assumed that an atom could break up in multiple ways. Yet if chemists, Soddy, Fleck, Hevesy, had not come to aid and shown that a fraction of a cubic millimetre of gas could be studied, and if Russell, Fajans and Soddy—we give the names in the sequence in which Sir Ernest quoted them—had not almost simultaneously arrived at their generalisation, the existence and position of the 30 new elements would still have remained mysterious. But they proved that an element would change its position on the table by two places when losing an α particle, and by one place in the other sense when losing a β particle, and that "isotopes," chemically inseparable and indistinguishable elements could occupy the same position and have the same spectra though differing in atomic weight.* Those views implied that different lines of disintegration (of thorium and radium, *e.g.*) would yield the same end product, lead, but that the different leads would not have the same atomic weight. That had been confirmed independently by Soddy, Th. Richards, and Hönigschmid. The lecturer himself had shown with Andrade that radium B was identical with lead and that there were three or four radioactive leads, the nuclei of which were of different constitutions in accordance with the modern ideas of the constitution of the atom. The investigation of neon by Aston also seemed to suggest that atoms of supposed elements might be mixtures.

Having referred to the different radiations from radioactive substances, Professor Rutherford passed to another fundamental discovery, that of the characteristic radiations by Barkla, in 1905, which again helped to bring order into the chaos of secondary radiations. That discovery indicated that X-rays were a type of wave motion. Then Laue discovered in 1913 that X-rays passing through crystals were diffracted, and from that sprung two most important lines of researches, the study of crystal structure and the study of the X-rays. The latter led Moseley—then working in the lecturer's laboratory at Manchester—to investigate whether any relation existed between X-ray spectra and the atomic weights; Moseley found that the atomic number was something more elementary and more characteristic still than the atomic weight. He could thus predict the actual number of possible elements, and Moseley's arguments had been extraordinarily fruitful in the whole inquiry into the constitution of the atom, a field in which Bohr had achieved striking success. Bohr had not given a theory of radiation; but he had determined Balmer's constant and explained such features as the Stark effect in the atom.

Coming, finally, to the latest development of X-ray work by the aid of Coolidge tubes, Professor Rutherford referred in particular to the study of the absorption spectra of the rays. Exhibiting some remarkable photographs of absorption spectra due to de Broglie and A. W. Hull, the lecturer said that recent experiments explained observations made by himself, Barnes and Robinson in 1915. They had then absorbed end rays from Coolidge tubes by aluminium after passing them through 2·49 mm. of lead, and they found that the aluminium-absorption was not changed as the exciting volts in the Coolidge tubes were raised from 144,000 to 175,000. The reason was that, according to Hull and Miss Rice, the radiation then issuing from lead consisted mainly of a characteristic radiation for which the absorption coefficient per cm. had the value $\mu = 22$. They found that the absorption coefficient μ in lead followed a certain law as long as the wave-length λ was greater than 0·149 Ångström unit A; for smaller λ the μ and the μ/ρ (the mass-absorption coefficient, where ρ was the density) suddenly changed owing to the presence of the peculiar absorption bands mentioned. In his most recent experiments Professor Rutherford had gone up to 196,000 volts, and he had then, again, noticed that there was little change of μ as the volts rose from 105,000 to 144,000, when the radiation was absorbed nearly exponentially. Above 144,000 volts the absorption, however, was no longer exponential, but μ decreased progressively with the thickness of the lead screen, *e.g.*, from $\mu = 26$ to $\mu = 12$ for 183,000 volts when the thickness of the lead was increased from 0·7 mm. to 7 mm. In order to avoid this complication due to a characteristic radiation from heavy metals like lead, he had first, in further experiments with aluminium, absorbed the greater part of the radiation by passing it through a metal of low atomic weight like iron.

These experiments had thrown light on the difficult question of the wave-length of the most penetrating γ-rays from radioactive substances. The minimum wave-length could be deduced from the voltage and *vice versa*, assuming the quantum relation $E = h\nu$ to hold. The best experiments of this kind had been made by Ishino, who deter-

* Compare Professor Soddy's discourse on the Complexity of Elements, ENGINEERING, May 25, 1917, page 500.

mined the μ/ρ and the mass-scattering coefficient σ/ρ separately; the latter he found for γ-rays to be 0·045 for aluminium, and 0·034 for lead, values which were much smaller than those found for X-rays. According to those experiments of Hull and of Ishino the μ/ρ in aluminium decreased from 0·154 to 0·085 and 0·026, and those in lead from 1·5 to 0·75 and 0·042, as the λ decreased from 0·147 to 0·063 and to the unknown wave-length of γ-rays, when the volts were raised from 84,000 to 196,000 and to the unknown volts of γ-rays. Thus the μ/ρ decreased very slowly between 84,000 volts and 196,000 volts, even at a slower rate than the first power of the wave-length λ, whilst for longer waves the μ was known to vary as the cube of the λ. But the change of μ/ρ was much more rapid for lead than for aluminium, as was to be expected; the figure 0·085 was only three times as large as 0·026, whilst the 0·75 was 20 times as large nearly as 0·042. The μ/ρ and σ/ρ seemed, with decreasing wave-length, finally to become of the same order, and there was probably a connection between absorption and scattering, such that for very small the two would reach a minimum value independent of λ. The shortest wave-lengths of γ-rays which Rutherford and Andrade had observed were 0·072 and 0·099 A, corresponding to 174,000 volts and 125,000 volts respectively. The μ/ρ for X-rays of these voltages would be 0·09 and 0·12, whilst the μ/ρ observed for the most penetrating γ-rays was only 0·026, as stated. Hence the wave-length of the most penetrating γ-rays was probably much smaller than had so far been assumed; from the figures (given above) it looked in fact as if it would require from 3 times to 20 times the volts actually used, *i.e.*, 600,000 volts or 2,000,000 volts, to produce γ-rays of $\frac{1}{100}$th wave-length of the soft γ-rays from Ra B.

Now the β-rays from Ra B and Ra C gave a veritable bright line spectrum when examined in a strong magnetic field, each group line consisting of electrons expelled with characteristic definite velocities. If the observed groupings were due to the conversion of the energy $E = h\nu$ of a wave-frequency ν into electronic form, the energy of the β-ray groups might be utilised (by the quantum relation) to determine the wave-length of the most penetrating γ-rays. The results of these studies (by Rutherford, Robinson, and West) suggested that the groupings of β-rays were due to the transformation of γ-rays in single (not in multiple) quanta according to $E = h\nu$. By the crystal method they had been unable to detect waves shorter than those Sir Ernest had found in conjunction with Andrade. But if the quantum relation should prove to hold for the very highest voltages, the magnetic spectrum of β-rays would afford a valuable method of extending the investigation of X-ray spectra into the region of very short wave-lengths. The complexity of the β-ray spectrum for Ra B and Ra C indicated that the spectrum of γ-rays and presumably the very high frequency spectra of the heavy elements, were as complicated as the ordinary light spectra of such elements. Thus, we might add, the complexity of spectra would be intelligible on other lines than those which Sir Joseph Thomson recently suggested in his Royal Institution lectures.

THE UNITED STATES RAILWAYS.

THE average operated length of the United States railways for the year ended June, 1917, was 259,611 miles, as compared with 257,000 miles in 1914–15 and 228,000 miles in 1907–08. The operating revenues for the same years were respectively 3,960,162,267 dols., 2,978,000,000 dols. and 2,422,000,000 dols. In the twelve months from July, 1916, to June, 1917, the operating revenue averaged for the first time 330,000,000 dols. per month. In the same period, the operating revenue amounted to 15,254 dols. per mile of line. Still in the same period the operating expenditure amounted to 2,683,567,831 dols., equal to 10,337 dols. per mile of line, or a ratio to revenue of 67·76 per cent. The figures of revenue and expenditure for the year 1916–17, which we take from the Railway Statistics of the United States of America, fourteenth year, are given in detail in the next column.

Operating revenue:	Dols.	Per Cent.
Freight	2,804,903,646	70·83
Passenger	778,928,667	19·67
Mail	63,919,683	1·61
Express...	102,633,393	2·59
Other transport revenue	112,529,108	2·84
Non-transport revenue	97,247,770	2·46
	3,960,162,267	100·00

Operating expenditure:	Dols.	Per Cent. of Revenue.
Maintenance of ways and structures ...	463,329,504	11·69
Maintenance of equipment	654,134,425	16·52
Traffic expenses ...	66,162,116	1·67
Transportation expenses	1,382,605,295	34·91
General expenses ...	94,476,573	2·39
Miscellaneous	22859,918	0·58
	2,683,567,831	67·76

	Dols.	Per Cent.
Net operating revenue ...	1,276,594,436	
Ratio to revenue ...	... ...	32·24
Taxes	180,361,652	
Ratio to revenue ...	... ...	4·56
Net operating income ...	1,096,232,784	
Ratio to revenue ...	... ...	27·68
Equal per mile of line	4,222	

On December 31, 1916, there were in the United States 8·62 miles of line per 100 sq. miles of territory and 406 inhabitants per mile of line.

The following comparison of the prices actually paid for railway equipment and material in 1907 and 1917 is interesting. A heavy goods locomotive which cost 16,243 dols. in 1907 cost 47,081 dols. in 1917, or an increase of 189·8 per cent. The cost of a passenger locomotive was 16,057 dols. and 33,142 dols. respectively, or an increase of 106·4 per cent. That of passenger carriage 7,330 dols. and 9,506 dols., or an increase of 29·7 per cent. The cost of rails per ton was 28 dols. and 40 dols., an increase of 42·7 per cent. This list could be extended to include every item entering into the maintenance of equipment and plant, showing advances varying from 20 per cent. to as high as 269 per cent. on driving axles.

In the calendar year 1916, the employees on the United States railways numbered 1,729,520, equal to 681 per 100 miles of line. They worked 5,444,176,600 hours and received in pay 1,535,257,800 dols., equal to an average of 887 dols. per employee and to 28·2 cents per hour. In the same year, the ratio of compensation of labour to gross earnings was 41·09 per cent.; the ratio of compensation of labour to operating expenses 62·63 per cent.; and the ratio of expenses and taxes to gross earnings 70·04 per cent. The net railway capital of the United States railways on December 31, 1916, was 15,880,153,279 dols., equal to 63,462 dols. per mile. Returns to the Bureau of Railway News and Statistics for the year ended December, 1916, received from 482 companies operating 250,233 miles of line, reported the number of stockholders at the last election prior to that date as 522,095. As there were approximately 20,000 stockholders in the smaller operating companies, and two years ago the non-operating roads reported 82,846 stockholders to the Commission, it would appear that the ownership of the railways of the United States rests in the hands of approximately 620,000 stockholders. The distribution of railway bonds was probably more general than that of railway stocks. At a meeting of the National Association of Owners of Railroad Securities, held at Baltimore last May, it was reported that the railroad securities owned were as follow: By individuals, numbering about 1,000,000, owning over 10,000,000,000 dols.; by life insurance companies, with 46,000,000 of policies in force, representing a total of 1,550,000,000 dols.; by savings banks with 10,000,000 depositors, representing 847,000,000 dols.; by fire and marine insurance companies, casualty and surety companies with holders representing a total of 649,000,000 dols.; by benevolent associations, colleges, schools, charitable institutions, 350,000,000 dols.; and by trust companies, State and national banks, 865,000,000 dols.

In the year to December 31, 1916, 35,007,574,000 passengers were carried 1 mile, at 2·045 cents per mile, and 365,034,029,000 tons of goods were carried 1 mile at 7.198 mills per mile. The figure for goods carried in the year to December 31, 1916, is a record one; it exceeds the total for the fiscal year to June 30, 1916, by over 22,000,000,000 ton-miles, and exceeds by more than 50 per cent. the ton-mile total of 1907 which formed the peak by which freight performance had been measured for the better part of a decade. The fact that in the face of a rising tide of cost in every department of railway service, this vast volume of traffic had been carried at an average rate within five-thousandths of a cent. of the lowest in the record, according to the statistics from which we quote, is of coincident importance to American industry.

The cost of locomotive coal in the year to December 31, 1916, was 257,371,124 dols., of which 216,152,033 dols. was for road locomotives and 41,219,091 dols. for yard locomotives.

NOTES.

A FALSTAFFIAN RECKONING.

IN a memorandum issued last Friday, the net cost of the Army in 1916–17, the second year of the war, is stated to have been 587,796,567*l.*, of which enormous total the sum of 285*l.* was appropriated to inventors. The disproportion recalls Falstaff's famous reckoning where one poor halfpennyworth of bread figured as an item amongst an intolerable deal of sack. The remark has often been heard that this is an engineers' war, but the above account would convey the impression that the authorities are as reluctant as ever to encourage the application of original thought to the improvement of our material of war. Fortunately, however, engineers and scientific men are less keen on "chequing" their patriotic efforts than barristers or coal miners, and hence, whilst the account may state truly the amount paid for ideas, it affords no criterion for estimating the actual value of the services rendered by inventors. It would, for example, be difficult to estimate adequately the monetary value of the Stokes' mortar, and the services rendered by Professor Jackson in making good the lack of German optical glass must alone have been worth many times the total amount provided for the reward of invention. The authorities have been not a little slack in acknowledging the value of the services received from inventors, which have in many cases been rendered gratuitously.

COTTON.

Some highly-interesting points were brought forward in a paper read before the Society of Arts, on Wednesday last, by Dr. W. L. Balls, who was for many years biological expert to the Khedivial Agricultural Society of Egypt. As is well known, the area under irrigation in Egypt has been enormously extended of late years, but, in some regards the results have been disappointing. In fact, whilst the total quantity of cotton produced has risen in twenty years in the ratio of 6·5 to 6, the area planted was increased during the same time from 1,100,000 acres to 1,700,000 acres, so that the yield per acre has fallen off most seriously. A tendency to diminishing yields was noted as far back as 1904, and many suggestions were made as to its cause. In 1906, Mr. J. R. Gibson, the English Commissioner for the State Domains, told Mr. Ball that there seemed good evidence in favour of the view that the fall in yield was due to a general rise in the level of the sub-soil water, which had been brought about by the extension of the irrigation system. The theory thus advanced was highly unpopular at the time, but ultimately proved to be perfectly sound. Dr. Ball, in explaining the effect of this rise of the sub-soil water, states that the root of a plant is a living thing, requiring oxygen for its respiration, and certain to die if kept immersed in stagnant water. That drainage was about as important as irrigation was insisted on by Sir Colin Scott Moncreiff, the founder of the Egyptian irrigation service, but under his successors less attention was paid to drainage than to supply, and the result has been the diminution of yield referred to above. Another matter of engineering interest was also described by Dr. Ball. Cotton has, in the past, been graded by certain specialists. A tuft of hairs is pulled from the lint by the grader, and laid on his coat sleeve. The length of the majority of the hairs is then assessed, the matter being largely a matter of individual judgment. A machine devised by

Dr. Ball yields, on the other hand, perfectly definite results. In essentials it consists of a pair of rotating rollers. These are brought up to the lint, and on gripping the latter, are pulled away again, whilst still continuing to rotate. A tuft of cotton is thus pulled from the lint. The short hairs in this tuft escape from the grip of the rolls earlier than the long hairs, and can thus be removed and directed into a different receptacle from that into which the long hairs are delivered. The action of the machine is automatic, and in two minutes it yields definite and accurate data as to the relative proportion of the different lengths of hair in the sliver.

The Dynamic Balancing of Marine Turbine Rotors.

In a recent issue of the *Journal of the American Society of Naval Engineers*, Commander F. J. Cleary, U.S.N., describes the methods used at the Mare Island Navy yard for balancing the rotors of the U.S.S. *Shaw*. These belonged to the first turbine propelling machinery built at the yard, and in view of the fact that excessive vibration had been reported on the actual working of many marine turbine installations, it was decided to take special pains to secure an accurate dynamic balance of the *Shaw's* machinery. The method used was to mount the rotor in bearings capable of sliding horizontally on their seats, but restrained into a central position by means of springs. A direct-current electric motor flexibly coupled to the rotor enabled the latter to be driven at any desired speed. At one end of the rotor a large disc of aluminium was affixed, having formed in it an involute slot. Behind this slot was fixed an electric lamp completely enclosed, save for a slit yielding a vertical line of light. A portion of this line of light was visible through the involute slot, and when the rotor was set in motion the effect was that of a spot of light moving up and down. The light from this spot was received by a fixed mirror and reflected by it to a second mirror capable of oscillating about a vertical axis. This second mirror was attached to one of the sliding bearings aforementioned, so that if this bearing vibrated the mirror was also set in oscillation. This oscillation caused the spot of light to move horizontally, so that when this spot was focussed on to a ground glass plate, the effect was that of an oscillatory horizontal motion superimposed on the vertical one due to the involute slot. If there were no vibration, the mirror did not oscillate, and the spot of light simply described a vertical line on the screen. Rotor vibration, on the other hand, gave a wave form of path which represented to a greatly magnified scale the actual movement of the rotor. The results showed that an excellent static balance might be obtained with a rotor far from dynamically balanced. The H.P. rotor of the *Shaw*, when completely finished, show no want of static balance when tested on the knife edges, yet required an addition of 40 lb. to put it into dynamic balance. The removal of one of the balance weights, weighing only 30 oz. (the weight of the rotor being 14,500 lb.) gave rise at 220 r.p.m., to a vibration which was distinctly visible to the eye, although its amplitude, as accurately determined by the optical apparatus above described, was only $\frac{1}{96}$ in. The propellers were also carefully balanced dynamically. In this case, it was found economical to omit the usual static balancing altogether as the dynamic balancing tests showed that some of the material removed in securing static balance would have been better back in place. The results of this careful balancing of the *Shaw's* machinery are said to have been highly satisfactory.

Engineering Trades (New Industries) Committee. Motor Industry.—At the request of the Association of British Motor and Allied Manufacturers, Dr. Addison, Minister of Reconstruction, has nominated Mr. H. C. B. Underdown to serve upon the Engineering Trades (New Industries) Committee, and has authorised the formation of a Branch Committee for the motor industry, of which Mr. Underdown will act as chairman. Mr. Underdown, in consultation with the said association, has formed his Branch Committee as follows: Mr. Bernard Caillard (vice-chairman), Mr. Edward Powell, Mr. J. B. Stocks and Mr. Horace Wyatt (who will also act as secretary). It will be noted that the Branch Committee recognises by its constitution the sections into which the industry is divided. Arrangements are being made for the formation of sub-committees representative of various branches of the industry.

LITERATURE.

Practical Electricity. By Terrell Croft, Consulting Electrical Engineer. London: Hill Publishing Company, Bouverie-street, E.C. 1917. [Price 10s. 6d. net.]

Mr. Terrell Croft is well known as the author of several works explaining the technique of electrical processes, and has learnt how to adapt his matter and style to the reader whom he is addressing. On this occasion his object is to present "the fundamental facts and theories relating to electricity, and its present-day applications in a straightforward, easily-understood way, for study by any man of little mathematical training, who desires to acquire a working knowledge of the subject." It will be found that his hand has not lost its cunning, and that he has succeeded in exhibiting many of the details of construction, together with the guiding principles on which they rest, in a lucid, and agreeable manner. He is entitled to take credit for having accomplished his task without having recourse to mathematical notation, but the limitations imposed by this severe denial of a useful auxiliary are many and annoying. Sometimes an appeal for the acceptance of an unproved proposition is made to authority, as the "result of the application of the higher mathematics," but such occasions are rare, and more often considerable ingenuity is displayed in avoiding the assistance that elementary mathematics could easily furnish. To describe the book as "popular" would be misleading and perhaps unjust, considering how that word is often misconstrued: it might rather be regarded as descriptive, and admirably descriptive, for anyone purposing a serious study of electric technics would find here an excellent introduction to this wide subject. Those, too, who are engaged in the manufacture and manipulation of electrical apparatus, and are desirous to understand the reasons for the mechanical arrangements they produce, would benefit by the careful study of these pages. It might be easy to find some expressions which are not rigorously accurate, or which need qualifications to make them universally applicable, but if anyone is disposed to be severely critical, we would remind him that it is legitimate and often advantageous to forego hyper-accuracy, in order to present a broad general truth, leaving some minute degree of qualification for a more advanced period in the student's education. If we limit attention to the mechanical arrangements by which some startling results have been achieved, the book will be found both satisfactory and accurate.

But if Mr. Croft dispenses with mathematical assistance he is a master of the methods by which the student's attention is attracted and riveted to essential points. The typographical art is worked to its utmost to secure distinctness and display. If any justification were needed for the kind of advertisement employed, it might be found in the fact that no teacher and no laboratory is supposed to be at command. A good example of the author's methods is to be found in the diagram constructed to enforce the importance of Ohm's law, and to familiarise the student with the various forms in which the law can be written. The diagrams, if occasionally bordering on the grotesque (page 71) are always impressive. They are generally excellent though sometimes inconveniently small. Every essential part is labelled, avoiding annoying reference to alphabetical lettering, often distracting and wasteful of time. In some cases, progressive variation is shown by a series of diagrams depicting successive stages of continuous change at regular intervals. For example, in illustrating the induction of an alternating E.M.F. by an alternator, the positions successively occupied by the field magnet throughout an entire cycle can be followed, an arrangement that certainly facilitates the comprehension of the principle involved, and in the absence of a teacher should be very useful. Conviction, or ready appreciation, is often sought by the use of "familiar analogies," but it may be doubted whether the correspondence exhibited in these illustrations, drawn mainly from hydraulic machinery, is as thorough and complete as the author imagines. We may admit the ingenuity displayed in representing, say, a two-phase, three-wire alternating-current generator and current by a hydraulic analogy, but where this feat is accomplished by postulating a "weightless fluid," the new thought introduced robs the illustration of all its simplicity and much of its force. In any case, however, if the student is not more familiar with hydraulics than he is supposed to be with electricity, the advantage of the plan is by no means obvious.

It is fortunate, as the author points out, that it is not necessary to know of what either electricity or magnetism consists, in order to utilise their known phenomena in mechanical application for the service of mankind. He holds by the electron theory, as affording a sufficient and rational explanation of nearly all electrical action, but practically he has found it convenient as offering "a definite physical conception of things" to treat electricity as analogous to a fluid, at the same time emphatically asserting that electricity is not a fluid. Since the object is to present and explain practical results, Mr. Croft might without detriment to completeness have dispensed with the opening chapters on Electrons, a collection of facts that as presented must startle without convincing, and excite curiosity without satisfying it. If the object were to deduce a solar theory it would not be thought necessary to discuss any suggested origin of gravitation, and in the same way, electrical energy can be assumed though one knows not either its origin or how to generate it, otherwise than as a transformation of energy.

The general arrangement strikes us as coherent and satisfactory, working first through the behaviour of electric circuits, then the magnetic circuit, leading up to the applications of electromagnets. This arrangement somewhat delays the introduction of the subject of primary cells and batteries, but if the author denies himself the opportunity of arresting the student's attention by early reference to an interesting topic that can be easily grasped, the road has been logically prepared for the after discussion of more intricate arrangements. Considerable space is devoted to the subject of primary cells, and to the consideration of the most appropriate form for particular classes of work. A fuller description might have been given of the Weston standard cell and in the description of storage batteries we fail to note any reference to losses due to sulphating.

This preparatory work occupies the first half of the book, and has prepared for the introduction of the large subject of electromagnetic induction, whose importance in commercial development cannot be overrated. Without apparatus, with pitfalls plentifully scattered, and the wayward tendency of students to make excursions into alluring, but unprofitable paths, the task of the teacher is hard and severe. The author is to be congratulated on having preserved a steady adherence to main lines, ensuring a consecutiveness that enables him to cover a large extent of ground. If the difficulties are increased, so no doubt will be the student's interest, for as a rule he is glad to escape the more theoretical portions to revel in the mechanical and experimental details that have led to material and industrial progress.

Inductance, which has to be tackled, is not a simple subject, and within the limit devoted to it some selection has been necessary. It is not easy to judge how far the author's account will be understood by a student, who travels this road without other assistance, for it is impossible to say where his difficulties may arise and at what point he will need further guidance, but however ample the account may appear, it is inevitable that very considerable effort will be required from the reader. Generators, field magnets, armature windings, and motors, all come under consideration, in separate sections, and being handled in a very practical fashion, the descriptions will appeal to a mechanical mind.

With the introduction of the characteristics of alternating currents and the principles of alternating-current generators, the author is hard pressed to avoid some mathematical deductions. Very rightly he ventures to show how alternating currents may be added and subtracted, and gives simplified examples of vectors and vector diagrams.

Apparently he has some difficulty over the maximum and average value of an alternating E.M.F. The quantities 0.707 and 0.636 appear to be given with some awe "as the result of the application of the

exact methods of the higher mathematics." The factor 1.11, so familiar to the designers of alternating-current apparatus, seems to be smuggled into a general table of formulæ without adequate explanation, but it is not difficult to show that when the voltage follows the harmonic law, the effective value is 1.11 times the average value. Some of the readers would certainly have understood that this factor is the approximate value of $\pi/2\sqrt{2}$, a deduction from the properties of the sine curve.

"Reactance," "Impedance" and "Capacity" are all hard matters to the beginner, but the author accepts the several difficulties manfully, and attains a very fair degree of success. Remembering that this is an elementary work, the treatment of power and power factor is adequate, but the author seems to have tired of his subject when he touches on the principles and applications of transformers. In the mechanism of these he has a far-reaching subject of a most attractive character, and as in the future the tendency will be to make more and more use of high-voltage electrical energy, the transformer will grow in importance and attract greater attention.

BOOKS RECEIVED.

Government Partnership in Railroads. By MARK WYMOND. Chicago: Wymond and Clark, Rand-McNally Building. [Price 1 dol. 50 cents.]

Technologic Papers, United States Bureau of Standards, Department of Commerce. No. 103. *Typical Cases of the Deterioration of Muntz Metal (60 : 40 Brass) by Selective Corrosion.* By H. S. RAWDON. Washington: Government Printing Office. [Price 10 cents.]

Illinois University Bulletins. No. 99. *The Collapse of Short Thin Tubes.* By A. P. CARMAN. Urbana, U.S.A.: University of Illinois; London: Chapman and Hall. [Price 20 cents.]

United States Bureau of Labour Statistics. Whole Number 216. *Accidents and Accident Prevention in Machine Building.* By LUCIAN W. CHANEY and HUGH S. HANNA. Washington: Government Printing Office.

Calcul des Systemes Elastiques de la Construction. Par ERNEST FLAMARD. Paris: Gauthier-Villars, Quai des Grands-Augustins, 55. [Price 12 francs.]

Text Book of Ordnance and Gunnery. By Lieut.-Colonel WILLIAM H. TSCHAPPAT. First Edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 30*s.* net.]

Theory of Structures. By ARTHUR MORLEY, M.Sc., M.I.Mech.E. New Edition. London, New York, Bombay, Calcutta and Madras: Longmans, Green and Co. [Price 14*s.* net.]

Journal of the Institute of Metals. Vol. XVIII. Edited by G. SHAW SCOTT, M.Sc. London: The Institute of Metals, 36, Victoria-street, S.W. 1. [Price 21*s.* net.]

Handbook of Ship Calculations, Construction and Operation: A Book of Reference for Shipowners, Ship Officers, Ship and Engine Draughtsmen, Marine Engineers and Others. By CHARLES H. HUGHES. London: The Library Press, Limited, 26, Portugal street, W.C. [Price 22*s.* 6*d.* net.]

Airfare of To-day and of the Future. By EDGAR C. MIDDLETON. London: Constable and Co., Limited. [Price 3*s.* 6*d.* net.]

Whitaker's Almanack for the Year 1918. London: 12, Warwick-lane. [Price 3*s.* 6*d.* net.]

British Meteorological and Magnetic Year Book, 1914. Part IV. *Hourly Values from Autographic Records,* 1914. London: The Meteorological Office. [Price 5*s.* net.]

Annual Report of the United States Coast Guard for the Fiscal Year ended June 30, 1917. Washington: Government Printing Office.

The Work and Training of the Royal Naval Air Service London: Office of *The Illustrated London News.* [Price 2*s.* 6*d.* net.]

Jane's Fighting Ships, 1917, *an Encyclopedia of the Navies of the World.* Acting-Editor MAURICE PRENDERGAST. London: Sampson Low, Marston and Co., Limited. [Price 25*s.* net.]

Mathematics for Engineers. Part I. *Including Elementary and Higher Algebra, Mensuration and Graphs, and Plane Trigonometry.* By W. N. ROSE, B.Sc.Eng. (Lond.). London: Chapman and Hall, Limited [Price 8*s.* 6*d.* net.]

Bath, in History and Social Condition. By AN APPRECIATIVE VISITOR. London: John Murray. [Price 2*s.* 6*d.* net.]

The Great Debenture or the Passing of National Unrest. By CECIL WALTON, O.B.E. Glasgow: Maclure Macdonald and Co. [Price 1*s.* net.]

Motor Repair Work for the Amateur Mechanic and Owner-Driver. Second Edition. London: Temple Press, Ltd. [Price 1*s.* 3*d.* net.]

THE "PRACTICAL ENGINEER" ELECTRICAL POCKET BOOK.—This pocket book and diary for the current year, the nineteenth year of issue, is published at 1*s.* and 1*s.* 6*d.* by the Technical Publishing Company, Limited, 1, Gough-square Fleet-street, E.C. It contains close upon 600 pages of useful information on the generation of current and on all the multitudinous applications of current. The diary portion covers one week per page, then follow French, Spanish and Russian glossaries.

INDUSTRIAL NOTES.

MR. RICE, President of the American Institute of Electrical Engineers, and also head of the General Electric Company of America, which employs over 70,000 men, speaking at the dinner of the Midwinter Convention on the great task which lies before the country of winning the war, said:—"I wish to emphasise the fact that it takes time to produce really efficient co-operation. No new organisation can possibly work as smoothly and effectively as one which has had time to become perfected. Moreover, co-operation in Washington between departments will not entirely settle the matter. We have a duty to perform. There must be co-operation among the industries. We must forget to compete, and learn to co-operate with other units. But this is not all, we must have co-operation between the Government and industries, and to be effective, this means that both must be a party to the co-operation. If the Governmental heads use their vast power arbitrarily and unwisely, they can easily cripple the industries of the country, and thus delay victory for years. Take, for example, the matter of priority. This is merely one of the factors of production. All large industrial establishments handle such matters through a production department with a production manager at its head. If an inexperienced man were put in charge of the production of any establishment, he could, and probably would, with the best of intentions, reduce the productive efficiency of such an establishment by 50 per cent. within a few weeks. No man can be successful in an administrative position, large or small, who does not understand and practise co-operation as second nature; in fact, industrial organisations found that co-operation was so much more efficient and economical than destructive competition that they began to co-operate with other competing units, but were prevented by law.

"I believe that the problems facing us will be successfully solved in time, but we need more co-operation, more of the spirit of accommodation, all our patience and wisdom, and above all, a willingness to work to the limit."

THE Engineering Trades (New Industries) Committee's offices are in Armament Buildings, Whitehall-place, S.W. 1. Its principal function is to assist the engineering trades in dealing with the problems which will inevitably arise in conjunction with the establishment of new industries. It is important to the trades generally and to individual manufacturers in particular that the committee should be informed of all new projects for expansion of businesses after the war, with the object of securing as far as practicable regular supplies of raw materials, also of preventing the putting down of means of production greatly in excess of all possible requirements.

The members of the committee are themselves manufacturers of experience, and they are sincerely desirous of assisting all their fellow manufacturers. The latter are invited to state to the committee what are the difficulties they anticipate in regard to the extension of their industries after the war, when assistance will be given them with a view to overcoming those difficulties. There will most probably be a shortage in the supply of some raw materials for engineering purposes during a period following upon the close of hostilities, and it is practically certain that some materials will continue for a time to be controlled by the Government, and a priority for materials for new or for extended industries of a character approved by the committee may not improbably be granted to some extent on its recommendation.

We understand that the committee is of opinion that specialisation in manufacture should be encouraged, and that with a view to finding the greatest possible opportunities for the employment of labour, those industries in which labour forms a relatively large part of the cost of production will probably be specially favoured.

A small pamphlet, entitled "A Call to War Workers of the Engineering and Shipbuilding Industries," has come into our hands. It is written by Mr. F. H. Rose, of the Amalgamated Society of Engineers, who defines as follows the "shop-steward movement":

"There is much confusion as to who and what are 'shop stewards,' and as to the relation in which the great trade unions stand in regard to what is known as 'The Joint Engineering Trades Shop Stewards' Committee.' A much greater difficulty is involved in the curious fact that vast numbers—perhaps a majority—of union workmen are no better instructed nor more definite in their conceptions.

"Shop stewards are persons working in engineering establishments and appointed to certain clearly-defined duties. Their election in most districts is by the workers in the shops; in others, directly by the authorised District Committees. Their duties are to watch the detail interests of the operatives in their respective departments, and to report any alteration, encroachment or innovation made or attempted by employers and their officials. But their authority begins and ends in the responsibility to the local governmental body which appoints them. They are paid a small quarterly fee on the written reports which they are obliged to submit. Acting within these properly prescribed limits, the shop stewards are useful, even necessary agents of the unions.

"Shop stewards constitute a very recent addition to the recognised officialism of the trade unions. But the movement, commendable enough in itself, was obviously open to abuse. Shop stewards in various parts of the country formed committees declaredly for the purpose of mutual intercourse, conference, and exchange of views and information. Left to run loose and unguided, and obviously devoid of the sense of responsibility imposed by settled regulation and rule, they rapidly developed into centres of industrial Syndicalist propaganda and widened their operations until they became elements apart from and independent of the unions. By degrees, this association, self-appointed and totally unrepresentative, has assumed an authority and arrogance as intolerant as it is harmful to the unions.

"The grave indictment against this movement is not directed against it as a theory of industrial organisation; from that point of view neither analysis nor criticism is necessary. The trouble is that men professing to have the workers' interest and honour at heart should take advantage of their country's peril and extremity to promote a project which they must know to be provocative of the bitterest controversy and discussion, this at a time when concentration of purpose and energy is the first essential guarantee of a world-peace which all righteous men long for. 'Down tools' will not bring victory or the lasting peace it consummates, and 'ca' canny' is not the agent of social and industrial liberty.

"For the legitimate shop steward movement there is little to be said which is not commendatory; it deserves all the kindly and fraternal help and guidance of the higher officialism of the unions, and has, unfortunately, some cause to complain that this has not been much in evidence. But for men who steal its name, appropriate its machinery and divert its purposes and influence into dishonest and unlawful channels there is neither apology nor defence."

Other remarks by Mr. F. H. Rose, taken from the same pamphlet, are to the following effect:—

"During the course of this war, strikes paltry enough in their objects have done much to retard and embarrass the all-important production of the machine and metals industry. Mismanagement and incapable direction have had quite as bad an effect. But out of sight the greatest deterrent has been workshop slacking, and beyond expression the worst and meanest deliberately organised 'ca' canny' . . ." "It seems a pitiful thing that men should whimper about grievances at a time like the present. Workers in engineering shops and shipyards have not a single grievance which is not suffered in a more intense form by their poorer fellow-citizens and their equals. . . ." "Workshop conditions were never better than they are to-day. From the highest skilled artisan to the meanest labourer, workshop life is more dignified and respectable, though the work is perhaps more monotonous and prolonged than in normal times. . . ." "When our fellow-citizens know that the fomenters of many of the strikes of the past three years and of most of the campaigns of deliberate 'ca' canny' were men with no vestige of elective status, but merely apostles of Industrial Syndicalism, they may form a poor opinion of the character of the masses of organised labour who have been credulous enough to obey them. . . ." "The road to victory can only be made by our unremitting labour and solidified by our skill and devotion. To us, it must be either worth doing or not. If we sulk or idle while the enemy works, the responsibility will be ours and the shame of defeat will lie heavily upon our class. But if it is worth doing, let it be done, and let neither the industrial faddist nor the sedition-monger deflect our energies from so worthy and honourable a purpose."

The secretaries to the Midland Iron and Steel Wages Board have published the report of the accountants for the two months ended January and February, 1918, and have announced that the wages for puddling during the months of April and May will remain at 19*s.* per ton, and that all other forge and mill wages will remain unaltered. The average net selling price of bars, angles and tees, plate and sheets, hoops, strips and miscellaneous has been 15*l.* 12*s.* 3·87*d.*

It is announced that Mr. Thomas Ashton, who is 74 years of age, is retiring from the position of secretary to the Miners' Federation of Great Britain a position

which he has held since the founding of the Federation, twenty-nine years ago. He will still continue to act as secretary to the Lancashire Miners' Federation.

A paper on the "Conservation of the Coal Resources of the Country" was read last Saturday at a meeting of the Birmingham Association of Mechanical Engineers by Mr. A. E. A. Edwards, who showed that the adoption of large electric stations to supply whole industrial areas, similar to the one on the North-East Coast, which served 1,400 sq. miles, would result in reducing the coal consumption in the areas served to about a fifth of the amount used for power purposes at present. The difficulties in the way of the adoption of such stations were due to vested interests of the statutory companies already supplying each city or town, to the trouble and cost entailed in getting wayleaves for the high-tension overhead wires, and to the fact that all coal was not suitable for coking, as it was at Newcastle. He also suggested that if each town used the exhaust steam from their electric light engines for heating water to be circulated in the town for use for heating purposes and for hot water supply in houses, as was done in America, the heat value of the fuel would be greatly increased, leading to a large saving in fuel. Birmingham alone by an expenditure of about 3,000,000*l*, would reduce its coal consumption in factories and houses by nearly 1,000,000 tons a year.

Writing in *The Federationist* for the present month, Mr. W. A. Appleton enters a plea for the stabilisation of employment. "The most demoralising and enervating fear," he says, "is that of unemployment and the miseries that follow. Men face hardship with a great deal of equanimity, but no decent man faces idleness without terror. . . . Those who have had opportunities of watching men through long periods of unemployment will understand how certainly and with what accelerated ratio moral and physical inefficiency develops. . . . It is not merely in the interests of the individuals that employment should be stabilised; it is in the interests of the State, because labour is in itself capital, and to waste labour is to waste national resources. Moral as well as economic considerations demand that where the conditions of trade are such that it is impossible to keep staffs fully employed for the normal day, arrangements should be made to reduce the hours of employment instead of reducing the number of employees; improved facilities for the interchange of labour between one industry and another should also be developed." Mr. Appleton also adds that "wages should be fixed so that at the worst they would afford maintenance, and at other times not merely maintenance, but comfort and a promise of ultimate safety." He further states that "the maximum value can never be obtained from labour, nor can the maximum benefit accrue to labour while there remain any restrictions upon the use of machinery and the exercise of reasonable effort and intelligence. The advocates of 'ca' canny' overlook the fact that 'ca' canny' increases the cost of production and enhances the price to the consumer, who is, 95 times out of the 100, some fellow workman or workwoman. This is the least successful way of remedying industrial and social evils."

The Minister of National Service has, under the power conferred upon him by the Military Service Act, 1918, made an Order withdrawing exemptions from Military Service held wholly or partly on occupational grounds by certain men of various ages employed in a large number of occupations, who are in medical categories A, B1, and C1, or Medical Grades 1 and 2, or who have not been medically examined. The Order which is far-reaching in its effect, came into force on the 9th inst., and provides that the exemptions of the men concerned are withdrawn as from the 24th of the current month, after which date the men will be called up for military Service. The current regulations provide that applications for renewal of exemptions withdrawn by the Order (which can be made on authorised personal grounds only) may be lodged within seven days of withdrawal, *i.e.*, in this case by the 1st of May. A decertified man has no right to apply for renewal of exemption on occupational grounds, nor has his employer any right to make such an application on his behalf. The Order does not affect the calling-up of coal miners, port transport workers, or holders of Protection Certificates under the Schedule of Protected Occupations.

The Minister of National Service has now made special arrangements for substitution.

Local Advisory Committees (which are distinct from the National Service Representatives' Advisory Committees) have been established by the Minister of Labour in connection with each Employment Exchange; and generally these Committees have been recognised by the Ministry of National Service and the other Government Departments as the bodies for dealing with substitution. These Committees contain representatives of employers and workmen, with an independent chairman. The Committees will generally do their work through Trade Panels, containing equal representation of employers and workmen, belonging, where possible, to the particular trade of the man whose case is under consideration. The Committees and their Trade Panels will do all that they can to help Tribunals with advice in specific cases; and, particularly, in the finding of substitutes and in the placing of men who, in the opinion of the Tribunals, should be used as substitutes or otherwise for work of national importance; and Tribunals should make the fullest use of their services. The National Service Representative will be in a position to furnish the Tribunals with any further information which they may desire as to the Committees.

Where the employer may properly be expected himself to find a substitute, exemption should be refused, reasonable time being given to the employer to find the substitute. Where the Tribunal think that a substitute should be found on behalf of the employer, and that this should be possible within a short time, the case should be adjourned for the purpose. When a satisfactory substitute is available the case should be disposed of forthwith. Where the Tribunal are satisfied that exemption should not be refused but that the man should be made available for service immediately a substitute is forthcoming, they should grant exemption "subject to the condition that the exemption is to terminate forthwith on the provision of a substitute considered, in case of dispute, by the Local Advisory Committee to be satisfactory."

In addition to the substitutes who may be obtained from civilian sources, the Ministe- of National Service has arranged with the War Office that in suitable cases men of low medical category in the Home Army may be released in place of Grade 1 or Category A men. A card index has been prepared of all men in the Home Army, with particulars of the last two civilian employments of each man. Generally speaking, endeavour will be made first to obtain substitutes from civilian sources; failmg this, the National Service Representative will be in a position to ascertain whether, for a Grade 1 or Category A man, a suitable substitute can be obtained from the Home Army. In a number of cases, employers may have definite particulars of men previously in their employment who are now in a low category in the Home Army and whom they would be willing to take back, and in return to release Grade1 or Category A men. Tribunals should, in any case in which they consider that exemption would otherwise have to be granted, always ascertain whether an arrangement of this kind is possible.

Any cases of men in certified occupations must continue to be dealt with in accordance with the special provisions relating to this class. If the National Service Representative can show that a reasonably satisfactory substitute is available for a man in a certified occupation, this will be presumptive evidence that the man should be released for Military Service.

HIGH DUTY ELECTRIC TRANSFORMERS.—Notwithstanding the serious difficulties which have surrounded the acquisition by France of really essential raw materials, the country has not suffered through any want of such materials and is very much better situated in this respect than the enemy country, says the *Revue Générale de l'Electricité*. Nevertheless, it would be advisable to endeavour to economise as much as possible some items, and in electric installations, in particular, to restrict the use for transformers of special quality sheets having low hysteresis and stray current losses. At the present time, France is manufacturing in large numbers transformers which mostly run on full load, since they are used in conjunction with war work which is never at a standstill. If the manufacturers happen to lack special quality sheets having low hysteresis and stray current losses, they will have to use others of ordinary quality in which the losses are high. This will entail either a greater weight of copper, or heavier current losses, leading to a larger transformer tank and to a greater weight of oil, in the case of natural cooling installations. Both solutions are costly, and, moreover, copper and oil may become scarce. The only economical means of meeting the difficulty would be to put down large transformers having an intensified cooling, in the place of small or medium size transformers connected in parallel and having natural cooling. The lowest power for frequency of 50 periods might be 500 kv.a. Since the manufacturers of war material are working at full pressure, there would be no great harm in having higher iron-losses per unit of transformer than those which obtain in the case of several apparatus connected in parallel. Moreover, a large artificially cooled transformer manufactured with ordinary quality sheet iron will, generally, show less no-load losses than a series of transformers having the same total capacity and with natural cooling, made with good quality iron. It should be further remembered that the parallel connection is frequently onerous since the older transformers of a set are often of a more or less antiquated type.

RETROGRESSION IN THE PATENT OFFICE.

TO THE EDITOR OF ENGINEERING.

SIR,—I think it would be found, upon further investigation, that, with perhaps the exception of some of the staff of the Patent Office, most of those who are from day to day personally dealing with matters appertaining to the progress of applications for patent, will certainly not uphold the contention that the new system of numbering specifications has any advantage over the old system.

According to the twenty-fourth report of the Comptroller-General of Patents, the main advantage of the system of renumbering specifications, is stated to be that it enables abridgments of specifications to be published to date without destroying their numerical sequence, and thereby gives the most recent information to the public without impairing the facilities for search and reference. By the aid of a slight addition to the numbers as they appeared in the index of proceedings, there would have been no loss due to the publication of the abridgments not in numerical sequence; the said sequence would appear to lose its significance when the abridgments are classified, and it is the classified lists that are mostly used now in making searches.

It would not appear to have been a difficult matter to have published the abridgments in the order of the acceptance of the specifications without giving them two numbers. They might even have been published in the same Journal in which they were advertised as accepted, and we should then have the very useful subject-matter index of accepted specifications now published weekly, in the same Journal as that in which the corresponding abridgments appeared.

The new numbering has increased the work of watching the progress of applications. One has now to watch the application numbers until the specifications are accepted, and then keep a list of both numbers until the specifications are printed, because both sets cannot be issued in order in one list at the same time.

It might have been expected that the new system would have given an exact sequence of publication of the specifications, but this is not so, as gaps in the new numbers may be found every week.

The old system of numbering was so very distinct from that of the principal foreign countries, that, in itself it was, *inter alia*, a useful guide to the country in which an article marked with a particular number was patented.

Further, the new system of numbering has rendered it necessary to keep two sets of progress registers at the Patent Office library.

The drastic changes made in the official journal are generally considered as a *pro tem.* economy rendered necessary by the war, and the least one can say of them is that the Journal in its present form gives the maximum amount of essential information in the smallest possible space. The chronological list of applications as given in the old Journal was without doubt the most useful arrangement of the applications when used with the accompanying name and subject-matter indexes; the latter, of course, in any case, could only be of a provisional nature, but even so was found to be very useful in making searches.

Yours faithfully,
M. H.

THE MILITARY AUTHORITIES AND ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—The exigencies of the "Great Adventure" have prevented my seeing earlier your issue of December 21, 1917. I much regret to note that my impression as to the *laissez-faire* attitude of the Institution of Civil Engineers towards its army members in the "Staff for the Royal Engineer Services" (as suggested in my letter in your issue of December 14) is corroborated by the letter of the secretary of that Institution appearing on page 657 of your issue of December 21.

If, as he states, the military authorities have "generally considered favourably" the representations of the Institution Council, how is it that Institution members who happen to be commissioned officers of the S.R.E.S. still hold honorary rank only while specialist officers drawn from the other professions are granted substantive rank, how is it they still have to serve some thirty-seven years before reaching rank of lieutenant-colonel, while the doctors and the "vets." receive the same rank in about sixteen and twenty years respectively, how is it they are still denied the opportunity of attaining higher rank than lieutenant-colonel while the seniors of other branches (combatant and non-combatant) are ranked as brigadier-generals and upwards?

Has the Institution secretary so poor an opinion of the comparative merits of the service of the technical professions that he actually regards these differentiations as "recognising that service appropriately"? When he wrote that disparaging phrase was he aware that status and competency are measured in army circles in terms of rank, was he aware that "honorary rank" is generally reserved by the military authorities for those who rise from the ranks?

If substantive rank is fitting for a graves registrar in London, for financial advisers and for multitudes of similar appointments, will he explain how honorary rank only for technical officers employed with the Expeditionary Forces or on fortifications, &c., is an "appropriate recognition"?

If the secretary will look up the National Registration Act of 1915, he will find that engineers, architects, surveyors, doctors and veterinary surgeons are classified in one group. Why does he consider it "appropriate" that these unequal differentiations should be made when they enter the army as specialist officers?

Has the secretary derived his information from the

"Corps of Royal Engineers generally"? If so, he should bear in mind that the exceptional unprofessional treatment meted out to the S.R.E.S. officer has been at the instance of the Corps of Royal Engineers itself, a fact which has painfully forced itself on those other institutes which have taken a more active interest in the matter.

Seeing that the Medical Associations considered the proper rank of their army members so serious a question as actually to threaten a boycott some years ago, it is distressing to learn that the Institution secretary regards the question of the rank of its own members as "not within the province of the Institution." It would seem that the editor of *Truth* had too high a conception of the obligations of the Institution towards its members.

Practically every technical journal is noting week by week the scant respect shown by the military authorities towards the civil-trained engineer and architect, while comment on the growing lack of representation by the technical institutions is almost as frequent. The tone of the Institution secretary's letter seems to justify the comment.

I am, Sir, yours faithfully,
"SUUM CUIQUE TRIBUTO."

March, 1918.

CONCRETE COTTAGES.

TO THE EDITOR OF ENGINEERING.

SIR,—I was somewhat surprised that my brief note should have induced your correspondent "Trent Concrete, Limited," to make a reply. He appears to wish to make it a personal matter, and his letter is evidently intended to be satirical. It is in rather bad taste that he should have taken that attitude, as it does not in the least affect the rather definite facts stated in my previous letter, and I would venture to remind him that the subject is the suitability of concrete for the construction of small houses. By an exchange of opinions one hopes to approach the truth, hence the value of your correspondence column, but it should be strictly confined to the subject of discussion rather than correspondents attacked by individuals who give their experience for the benefit of the general public.

I am fully aware of the fact that the building of concrete houses in the States is a recognised industry, so, for your correspondent's information, is the construction of corrugated iron houses in Peru and Chili, so also is the bamboo hut business in the Malay Straits and China. I have been to these places, as well as the States, so I speak with knowledge. Because the States have built concrete houses it is not a recommendation by necessity. Very frequently the States have to follow British practice when the interests of the community are concerned, as opposed to vested interests. The general practice in the States is to make houses or machines to answer their purpose for a moderate time and then they are scrapped. British practice is much more substantial, and this probably accounts for the Americans' predilection for concrete.

I well remember in my last visit to New York seeing a large building of concrete that had been burnt. All the concrete had fallen away and left the stanchions more or less in position. Adjacent to this building was one of brick, equally burnt, but the walls were standing, and apparently still good, showing the brick to be much more durable.

Apropos of this subject, I well remember examining a concrete floor in a house. Cracks running the whole length had developed. It was found that steel girders, had been set in the cement, rusted to a considerable extent, and so burst the floor, and apparently that is what ultimately will happen with such constructions.

In the post-ultimate paragraph of the letter some figures are given. The ordinary brick wall for small houses is about 9 in.; your correspondent suggests concrete of apparently one-third the brick thickness. I venture to suggest that a cottage with 3-in. concrete walls would be anything but warm and comfortable. Non-verminous it might be, as any living creature would be destroyed by the intense cold.

Yours faithfully,
April 3, 1918. "BRITISHER."

LONG-RANGE GUNS.

TO THE EDITOR OF ENGINEERING.

SIR,—A great deal has been written as to the methods the Germans are employing to bombard Paris, and it would appear that the question of the design of the projectile itself has received very little consideration.

Mr. Stromeyer gives particulars of Mauser's experiments to improve the trajectory of a bullet, which on analysis simply prove that the projectile was made lighter for a given chamber-pressure and, of course, the muzzle velocity increased.

Most of the experts appear to agree that the increased range obtained by the Germans has been made possible by employing much higher muzzle velocities, which means that a greater pressure has to be exerted on the base of the shell.

The present muzzle velocities of projectiles from guns of large calibre are in the region of 2,400 ft. per second, and the pressure to produce this somewhere about 20 tons per square inch.

It has been stated that a muzzle velocity of 4,000 ft. to 5,000 ft. per second would be necessary to throw a shell 75 miles to 80 miles even allowing for the decreased air resistance during part of the flight, consequently a greatly increased gun chamber pressure would be necessary to provide this.

The designer of a projectile is somewhat restricted because it has been found that in order to obtain steady flight the length of a shell should not exceed 4 calibres to 4½ calibres in length, also that the centre of gravity should be in a certain position. False caps have been fitted to shell to decrease air resistance, but while these have increased the overall length of the shell, they have been of light construction so that the centre of gravity has not been much displaced.

Theoretically, the stress on the shell walls due to the pressure on the base should be the same throughout their entire length, but owing to restrictions above stated the position of maximum stress is to be found in the region of the driving band.

The stress in a shell wall is usually found from the following formula—

$$S = \frac{w \times P}{a \times W}$$

Where s = stress per square inch
w = Forward weight of shell above position of maximum stress (generally 0.5 inch above driving band).
P = Total pressure in gun chamber.
a = Area of section of steel walls.
w = Total weight of filled shell.

It is evident from the above that with the increased chamber pressure, to provide the high muzzle velocity required, the walls of the shell become exceptionally thick, and the cavity small, with the result that the destructive capacity of the shell on explosion is much reduced.

The Germans have no doubt used steels for their shell, giving high yields, but it is doubtful whether their use would enable an effective shell to be designed.

I have endeavoured to show that the design of an effective projectile will do much to limit the range of modern ordnance, because it would be absurd to throw shell having small bursting charges long distances.

I trust I have not taken up too much of your valuable space.

I am, Sir, your faithfully,
W. S. YARROW.

"Braeside," Bruce Road, Wealdstone, Middlesex.
April 4, 1918.

THE CANAL QUESTION.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with much interest your article headed as above, in your issue of the 29th ult., where you make reference to contentions I have advanced with regard to the development of inland water transport in England.

There are two points upon which I should appreciate your courtesy to permit criticism. The first is that in Continental countries—and I will deal with France—the success of inland water transport is due to the industrial districts, which are there so well served in the matter of water transport, being comparatively flat, and possessing large rivers, which lend themselves naturally to canalisation. You said that, whereas of our inland waterways, 4,053 miles in length, only 482 miles are natural rivers, in France out of 7,006 miles, 4,392 miles are river.

This being so, one would expect, if your inference is correct, to find that it is the rivers or canalised rivers which carry the greater proportion of French waterborne traffic, but I find that, in the latest years for which figures are available, the ton-mile traffic on rivers was only 1,349,000,000, against 1,804,000,000 on canals, giving a ton-mile circulation on rivers of 323,000 per mile, contrasted with 578,000 on canals. Further, many of the French rivers are so unsuitable for traffic in their natural condition, or even for canalisation, that it has been necessary to construct numerous canals parallel with the rivers, as their names suggest—Lateral a la Marne, a l'Oise, a la Garonne, a la Loire, &c.

Further, the maintenance and upkeep of works on the rivers of France cost 33 per cent. more per ton of traffic carried than on the canals.

Your second point I would criticise is that whereas in France the whole of the expense and upkeep of the canals is borne by the State, despite this subsidisation, canal transport fails to carry as cheaply as rail. You have, however, obviously overlooked the fact, that the French railways are also largely subsidised by the State, and, whereas the cost to the State, per ton-mile of canal-borne traffic has been estimated to average 0·21d., the contributions by the State and Departments to railway borne traffic work out at 0·16d. per ton-mile.

The writer also in indicating the necessity for a greater number of locks in England than on the Continent, cited the waterway between Berlin and Hamburg, which had become very familiar in this connection, where, in 230 miles there are only three locks, but even this facility has not tempted any very large volume of traffic, the ton-mile circulation being very much less than on the Canal St. Quentin, where there are 35 locks in 58 miles. Yet this canal has carried as large a traffic per mile as any river in France, including the Seine, and before the war had been so successful, and had so greatly stimulated the industries of the districts it serves, that a new one—the Canal du Nord—had been cut parallel to it to move the traffic with which it was unable to deal.

This is good evidence that physical difficulties do not bar successful water transport and that the creation of facilities induces traffic and industrial propriety. Instead of attributing the success of Continental inland water transport and our comparative failure to physical difficulties, I submit we should seek the cause in the neglect of development and improvement to our waterways.

Since 1880 France, Germany and Belgium have reconstructed theirs; ours are no better than at the beginning of the last century; and are quite unsuited to the demands of to-day. Through your influential columns, I submit, therefore, that, instead of folding our hands in the face of physical difficulties our engineers should, with Government aid, overcome them as in France on the canals St. Quentin, Du Nord, and Marne au Rhin, and in Belgium du Centre and Brussels—Charleroi, all canals with difficulties as great as those cited in your article as prevalent in English industrial areas.

Yours faithfully,
FRANK IMPEY,
Secretary Waterways Association.

37, Newhall-street, Birmingham, April 6, 1918.

[We fully appreciate Mr. Impey's excellent intentions and good work in connection with the problem of inland transport, and we realise that at the present moment economic consideration in transport must give way to the necessities of the nation. We need to make all the use of our present canals that is possible. But as to the future, we would recall Mr. W. H. Lindley's Report to the Royal Commission on Canals and Waterways. Mr. Lindley said: "No artificial canal can begin to compete with a railway built and operated for goods traffic only." Mr. Lindley had spent years on the Continent, and was intimately acquainted with its internal navigation, and, when asked by the Canal Commission for a comprehensive report on French, German and Belgian waterways, he summed up his opinion in the above words.—ED. E.]

THE INSTITUTION OF ELECTRICAL ENGINEERS' WIRING RULES.—The council of the Institution of Electrical Engineers have adopted a recommendation of the Wiring Rules Committee that Wiring Rule No. 62 shall not apply to consumers' electric supply meters for currents up to 100 amperes made in accordance with the Engineering Standards Committee's Specification No. 37.

PURCHASE, MANUFACTURE AND INSTALLATION OF ELECTRIC CONVERTER PLANT.—The Minister of Munitions has ordered as follows:—1. No person shall on or after the 5th inst., until further notice, purchase or manufacture, or erect or instal in or in connection with any factory, workshop, steel works, shipyard, colliery or other premises for the purposes of which alternating current is or can be made available, any rotary converter plant, motor generator plant or converter plant of any description for transforming alternating current to direct current, or any part of such plant (all or any of which shall be included in the expression "converter plant") except under and in accordance with the terms of a licence issued on behalf of the Minister of Munitions by the Director of Electric Power Supply. 2. Nothing herein contained shall prevent the carrying out of any necessary repair to converter plant already installed at the above date, or the purchase, manufacture, erection or installation of converter plant required solely for electro-chemical or electrolytic processes or electric traction. 3. All applications in connection with this Order shall be made to the Director of Electric Power Supply, Ministry of Munitions, 8, Northumberland Avenue, W.C.2. Applicants for licences are warned against purchasing or installing direct current motors before the licence for the necessary converter plant has been obtained.

THE MANNESMANN TUBE WORKS.—The above concern, which at its start almost entirely confined itself to the manufacture of tubes on the Mannesmann process, has by degrees expanded on a large scale, and in many directions, increasing largely both its capital and the scope of its undertakings. The share capital had risen to 72,000,000 marks, and a further increase of 14,000,000 marks has now been decided upon. Among the recent or pending extensions may be mentioned the taking over of the Schulz Knaudt rolling mill, near Düsseldorf, and the erection of blast-furnaces. In addition to the Unser Fritz coal mine, recently acquired, the company owns the Königin Elizabeth coal mine, Essen, which, within the coal syndicate has a selling allotment of 1,300,000 tons of coal, 400,000 tons of coke and 216,000 tons of briquettes, in addition to which the present allotted "self-consumption" is limited to 200,000 tons. The company has rolling mills at Remscheid, Busz-an-der-Saar and Düsseldorf-Rath, steel works at Saarbrücken and plate rolling mills at Gelsenkirchen-Schalke, and the newly-acquired mills at Huckingen. In regard to mining property, the company holds the two coal mines referred to above and several ore deposits. At present the company employs 21,721 hands and staff at its German and at its Austrian branches. The company has concluded selling arrangements with the Witten steel tube works, the tube works department of the Rhine steel works, the Gustav Kuntze Watergas Welding Company, at Worms, and the Siegen Railway Requirements Supply Company and Iron Works at Nassau-an-der-Lahn. The last balance-sheet, exclusive of recent increase of capital, shows bank credits amounting to 50,360,000 marks, and stock for 19,670,000 marks, in which war loans, German and Austro-Hungarian, form a prominent part. Amongst the shares held by the company and which in the aggregate amount to 26,390,000 marks, the Austrian Mannesmann concern figures for 15,000,000 marks. The amount of the shares in the British Mannesmann Tube Company have been written-off. The Italian Mannesmann works have been disposed of under the pressure of circumstances. The reserves amount to 22,730,000 marks, apart from 2,500,000 marks reserved for reconstruction and 4,000,000 marks for the re-establishment of a world trade. The dividend for last year was fixed at 15 per cent., besides a bonus of 3 per cent.; the dividends for the two preceding years was respectively 10 per cent. and 7½ per cent. The prospects for the current financial year are said to be exceedingly satisfactory and the deliveries are considerably larger than those of the corresponding period of the previous year.

THE KENT-NORRIS MECHANICAL LUBRICATOR.

CONSTRUCTED BY MESSRS. PLENTY AND SON, LTD., ENGINEERS, NEWBURY.

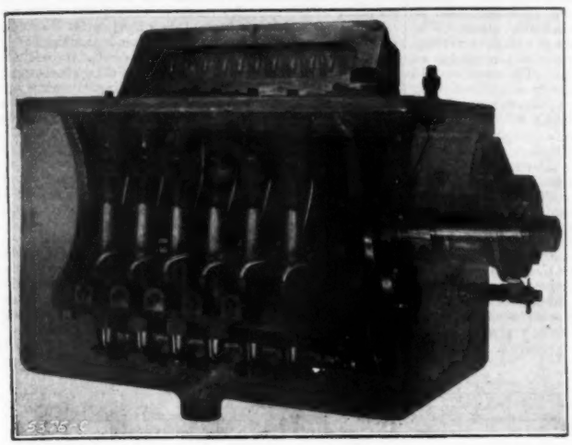
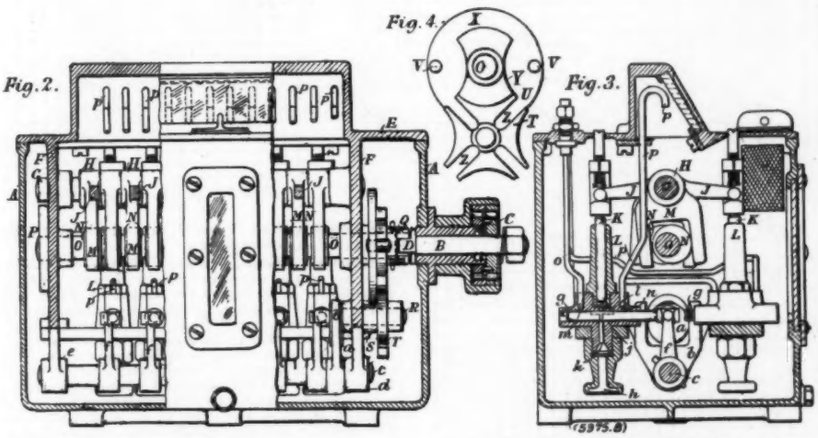
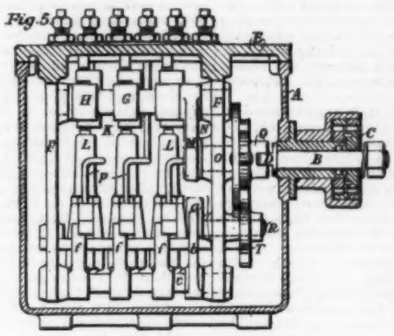
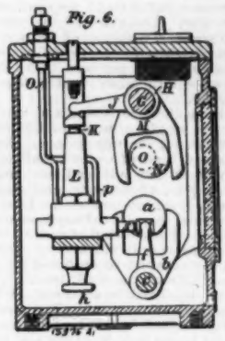


FIG. 1.







WE illustrate in the view Fig. 1, and in detail in Figs. 2 to 6, a multiple-plunger pump lubricator designed by Mr. Henry Kent-Norris, Ashdown, Pyle Hill, Newbury (Berks.), and manufactured by Messrs. Plenty and Son, Limited, also of Newbury.

The plungers are positively driven during both the suction and the delivery strokes, and the slide valves are positively operated by the working mechanism. Each pump has two different delivery connections and a slide valve which is arranged to direct the delivery of successive working strokes first to one and then to the other delivery connection. Alternate deliveries may thus be taken to a sight observation device for checking the working of the pumps. As will be seen from our illustrations, an intermittent transmission gear of the Geneva stop variety is provided between the plunger-operating shaft and the slide valve operating shaft, whereby the valve is held at rest in the suction or the delivery position during the strokes of the plunger. The plungers are reciprocated by oscillatory arms. Our illustrations show, Fig. 2, a sectional front elevation of the lubricator; Fig. 3 a transverse section through Fig. 2; Fig. 4 is an elevation of the Geneva stop mechanism; whilst Figs. 5 and 6 are a front elevation and a transverse section of a modified form of the lubricator.

By reference to Figs. 2 to 4, it will be seen that the reservoir containing the lubricant is marked A, in the right hand wall of which is mounted the driving spindle B. The spindle B is provided with a ratchet or toothed wheel C at its inner end to enable it to be driven step by step in one direction, and at its inner end with a coupling-piece D. The lid E of the reservoir is made in one piece with the inside extensions F which serve as brackets or bearing plates. The upper shaft G is a fixed shaft which extends from one bearing-plate F to the other and carrying hubs H, upon which are rocking arms J on either side for actuating the pump plungers K, the pumps L being on either side of the shaft. Forked arm yokes M are formed on the hubs H so as to turn with the rocking arms J, the yokes engaging with cams N secured on the shaft O directly below the shaft G. A removable bearing P is provided for the camshaft O at one end and at the other end the camshaft has a coupling member Q for engaging with the coupling-piece D on the driving spindle B. A short shaft R directly below the shaft O is mounted in a single bearing S in one of the bearing-plates F, and has at one end the star wheel or Maltese cross T of the Geneva stop mechanism, the wheel T being operated by suitable parts carried on the camshaft O; for this, a disc U (see Fig. 4) is provided, having on one face two diametrically opposite pins V for entering the slots of the star wheel T, there being also on this face a cam-shaped piece presenting two diametrically opposed arcs X of a circle, the arcs lying between the pins V, the ends of the arcs being joined by the concave edges Y. The star wheel T has concave parts between the slots Z, so designed that an arc X engages in one of the concave parts during the intervals between the engagement of one of the pins V with one of the slots Z. At each half-revolution of the disc U, therefore, a pin V will enter a slot Z and turn the star wheel round through 90 deg. The star wheel is thus held against rotation during the continuous rotation of the disc U until the next pin V engages the following slot Z.

The short shaft *R* is fitted with a cam *a* which engages with a yoke *b* in a hub secured on a bottom shaft *c*, which rocks and extends from a bearing *d* in one of the bearing plates F to a bearing *e* in the other bearing-plate F; the rock shaft *c* lying in alignment with the upper shafts, carries a series of upstanding arms *f* which engage horizontal valve rods *g*, as shown in Fig. 3, which also illustrates the pumps, valve chests and suction nozzles fitted with strainers marked *h*. Within each chest, the valve rod *g* is made with a vertical passage *j*, which aligns with the passage *k*, and a port *l* opening beneath the corresponding plunger K when the slide valve *g* is in the motion position as shown in Fig. 3. In each valve chest the valve rod is cut away so as to form a cavity of sufficient length for establishing communication between the port *l* beneath the plunger K and a delivery port when in an extreme position. When a slide valve is in the suction position, as shown in Fig. 3, the vertical passage *j* aligns with the suction duct *k* in the spigot and the port *l*, beneath the plunger K. When it is moved to the extreme position on the left-hand side, (see Fig. 3), it opens communication by means of the cavity, between the port *l* beneath the plunger and the delivery *m* on that side. After coming back to the suction position it moves over to the other extreme position and opens communication with the delivery *n*. The force-feed ducts are marked *o* in Fig. 3, and the sight-feed ducts, which are bent over at top behind a suitable window, are marked *p* in the same illustration. Thus each pump alternately makes a force-feed stroke and an observation feed stroke, and adjacent pumps simultaneously pump, the one to the sight-feed and the other to the force-feed delivery the sight-feed oil lubricates that part of the operating gear which is not submerged in the oil.

In the modified construction shown in Figs. 5 and 6 there are only three pumps L, and these are arranged to the rear of the shaft G, which in this case is a rock shaft, and carries three arms J for operating the plungers K. The shaft G has fixed to it a yoke M which is operated by a cam or eccentric N, and as the shaft O has only this single cam N it can be made short, as seen in Fig. 5, and need not extend from one bearing-plate F to the other. The valve rods *g* are operated in the same manner as in the preceding instance, but the deliveries *o* and *p* are both force-feed connections like the deliveries *o* and are not carried upwards behind an observation window; consequently these three pumps provide six forced deliveries.

In both lubricators the filling aperture is at top, beneath which is a strainer; the filling aperture is closed by a plug. The reservoir can be emptied for cleaning out purposes by removing a plug at the bottom of the casing.

REINFORCED CONCRETE VESSELS.*

By MR. WALTER POLLOCK.

(*Concluded from Page* 368.)

Classification Rules.—At present there are no recognised rules for the construction, although all the Classification Societies are studying the subject. The Norwegian Veritas have formulated some rules which include the following: The stress on the steel is not to exceed 6.35 tons per square inch when in compression and 5.08 tons per square inch when in tension. The modulus of elasticity of the concrete is to be taken as one-fifteenth of steel. The stress when in compression not to exceed 570 lb. per square inch, or one-sixth the strength of the concrete. The stress when in tension not to exceed 57 lb. per square inch. The maximum bending moment and shearing force for a vessel are assumed in relation to its longitudinal number, and are set out by curves (Fig. 11 overleaf). The assumed moment appears to be nearly 50 per cent. more than the actual moments found by calculations. The bending moments for floors, frames and beams are assumed (see curves 12, 13 and 14). These are related to the transverse number in the case of the floors, the transverse number multiplied by the height, for the frames, and the length in the case of the beams. The bending moment for the centre keelson is given in the curve (Fig. 15), and is related to the longitudinal number. When the vessel

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is more than 27 ft. beam, side keelsons, one on each side, to be fitted. The outer bottom, between the floors, is to resist a water pressure equal to 50 per cent. more than the maximum draught, and in foreign-going vessels for 30 per cent. amidships (25 per cent. of motors fitted aft), to resist a pressure of twice the vessel's maximum draught. The inner bottom, where fitted, to resist a pressure equal to 25 per cent. more than the maximum draught. The sides of the vessel between the frames to resist a pressure of 75 per cent. of the maximum draught, the forecastle 60 per cent., and the bridge or deck-house 50 per cent. The deck between the beams to resist a pressure equal to 35 per cent. of the maximum draught.

Stanchions to beams and hatch ends are supposed to bear a weight of water of 4.35 ft. on the main deck, and 2.85 ft. on the upper deck. A watertight bulkhead to resist a head of water equal to its height, plus 3.35 ft. The deck and bulkhead steel rods to be covered with at least ½ in. of concrete, and those in the bilges with at least ¾ in. of concrete. Where rods have to resist pressure, they are to be spaced not more than 15 diameters apart. The overlap of rods to be 60 times the diameter. Welding is only allowed by special permission. A solid fender of wood to be fitted for the whole length of the vessel above the load line. Ceilings and cargo battens must be fitted in all cases. When the hatch coamings are made of concrete, they must be boarded with wood or protected in some other way against knocks. The stern frame is to be of the size required for a steel vessel of similar size.

aggregate, and for shipwork the proportions are usually of 1 to 1½ to 1¾ by weight, although the author prefers to specify a mixture of 1 to 3 graded ¼ in. downwards. The cement usually obtainable is to the British Standard Specification, which provides for a residue on a sieve 180 × 180 = 32,400 meshes per square inch, not exceeding 14 per cent. The finer the grinding the better, and as manufacturers now often produce cement with up-to-date machinery, a residue of 6 per cent. to 8 per cent. might be insisted upon with advantage. The great point is to get a concrete that is not only strong, but impervious to water, for otherwise the reinforcement may rust and throw off the concrete. The sand should be clean and sharp, and pass through a sieve having square meshes $\frac{1}{10}$-in. in the clear; the grains should vary regularly between coarse and fine without a large proportion of either extreme. The aggregate must be clean and sharp and able to pass through a ¼-in. mesh, and be retained on a $\frac{1}{10}$-in. mesh. If the aggregate is large, the homogeneity, even when tamped, would not be as perfect as it should be. The best concrete will be obtained from crushed granite chippings from ¼-in. dust-washed. If crushed granite is not available, and it is proposed to use gravel, preliminary dry experiments can be made by filling a measure with the gravel and then finding the greatest amount of sand which can be mixed with the gravel and shaken into the same measure. This will be in the neighbourhood of 35 per cent. Ten per cent. more than this ascertained quantity should give the correct ratio. Smooth gravel should not be used, but crushed flint and crushed gravel will

from the mixture decided upon, tamped as described for the work, and, say, four blocks of each tested at 28 days, the compression load being slowly applied. The compressive resistance should be ascertained and the average of the results adopted as a standard.

Material of Reinforcement.—The steel for the rods is usually of shipyard quality of mild steel 28 tons to 32 tons per square inch tensile, although some reinforced concrete experts prefer medium carbon steel (to which category shell discard steel belongs) with 35 tons to 45 tons per square inch tensile, a contraction of area at fracture not less than 45 per cent., to withstand bending cold to 180 deg. around a diameter equal to twice that of the bar without fracturing the skin of the bent portion. All bars used to be bent cold, and any showing signs of brittleness in the process of bending to be rejected. It is undoubtedly a wise precaution to use only mild steel rolled sections and plates for shipbuilding where a good deal of bending is required and the main members are of such a size that they individually become units, on any one of which the whole safety of a ship depends, on account of flaws and internal stresses being introduced in the rolling which cannot easily be detected. There does not appear to be any risk in reinforcing with rods of medium steel, because, being of small size, they are not so subject to flaws and internal stresses, and are used in multiples, so that if one or more in a combination is defective the factor of safety is adequate protection; while by insisting upon all bending of bars being done cold and all bars being bent, every individual bar is tested on the bending table, and thus

Fig. 11.

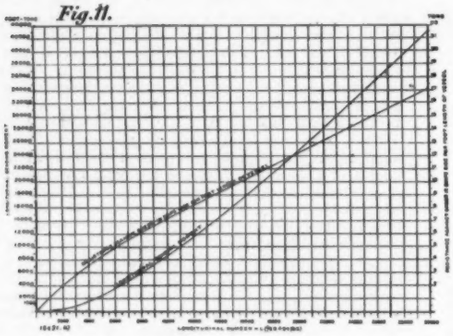


Fig. 12.

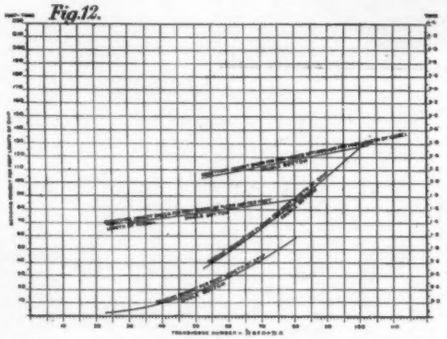


Fig. 13.

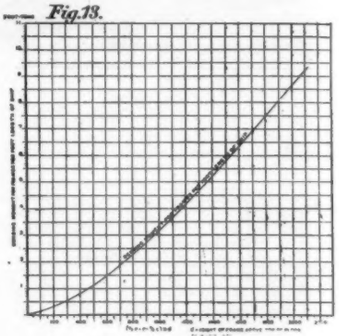


Fig. 14.

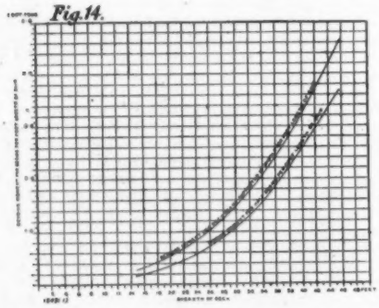
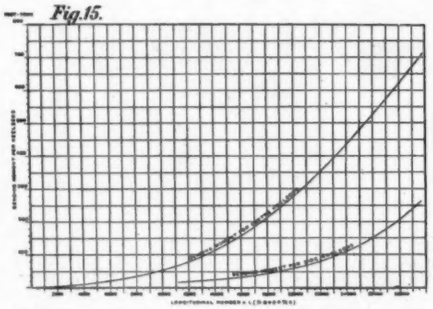


Fig. 15.



Lloyd's Register of Shipping are prepared to give an "A" Experimental Class to vessels approved by them, and will no doubt in due time prepare rules, as also the British Corporation Registry, Bureau Veritas, &c.

Types of Vessels Suitable.—Reinforced concrete is particularly suitable for coasting vessels, tugs of all types, sailing vessels, harbour and dock vessels, lighters and barges of all types, lightships, mooring and lifting lighters, floating piers, caissons, pontoons, floating docks and buoys. With tugs, weight is a distinct advantage, as all designers well know, for it enables them to hang on to the "tow" under adverse conditions, and, when docking, reduces the heeling over of the tug when the tow-rope is girted. In sailing and auxiliary yachts, the expensive lead and iron keels can be dispensed with if the hull and keel are made in reinforced concrete. Oil tankers can be constructed of reinforced concrete for carrying any hydro-carbon oils in the concrete tanks, and there is no reason why vertical side tanks should not be built of reinforced concrete for carrying oil fuel. Double bottom and side tanks have the advantage of increasing the number of watertight compartments and consequently the safety of the vessel. Concrete tanks, unless specially made for such exigency, should not be used for carrying any oils that generate free acid, i.e., animal or vegetable oils, or for carrying sugar or fruit, because the acids destroy the lime in the cement and disintegration is likely to take place. There is no objection to carrying sugar in bags or fruit in boxes, &c., as cargo in a concrete vessel, but it is a wise precaution to wash out the bilges, say, every few months.

Concrete Material—The best concrete is the concrete that is the densest—the principal consideration is its permeability. To obtain the necessary density the cement must be finely ground, the aggregate carefully graded and not too coarse, and the mixing thorough. If the concrete is too rich it is subject to greater contraction and cracks. It is made of cement, sand, and

do very well. In work of the importance of concrete shipbuilding, the contractor will be well advised to mix up cubes in which the ratio of fine to coarse material is varied slightly. When these are set and dried out, he can weigh them and soak in water, weighing the wet briquettes at intervals after wiping them to see which is absorbing the least amount of water. For all ordinary purposes he can take it that the one which absorbs least water will be best for his purpose all round, both in strength and permeability. Special care will be required to make sure that the aggregates tested are fair samples, and warning is necessary against taking the stone from the edge of a heap on account of its not being a fair sample of the whole. Similarly, when the concrete is being mixed for placing in the ship, the stone should not be entirely shovelled from the bottom of the heap, where it is always coarser than the average.

For grouting purposes and for fitting various iron parts in position after the concrete structure has been cast, it is better to use an equal mixture of cement and sand rather than pure cement, as the latter is more liable to contract and come away from the ironwork. There are two kinds of cracks that appear in concrete, hair or surface cracks, and setting or hardening cracks. The former are caused by a film of richer concrete getting to the surface, or through the concrete being faced with neat cement, and thus constituting a different mixture from the bulk of the concrete with a different coefficient of expansion and contraction. The latter cracks are caused by the difference in contraction of the concrete in air, as compared with the contraction when in water. Surface cracking may be avoided by keeping the aggregate in the concrete well to the surface and contraction cracks by keeping the concrete well wetted during setting. Expansion and contraction curves of a mixture of 1 to 3 are given in Fig. E, page 411, by which it will be seen that the linear expansion in water decreases with age, whilst the linear contraction in air increases with age. Test pieces of the concrete should be made

any brittle bars are detected, this constituting a check of a most important nature.

Structural Details, Concrete Work.—A minimum covering of the reinforced steelwork with concrete is desirable so as to reduce the weight of the structure, while, at the same time, it must be sufficiently strong to prevent the concrete from breaking away under the torsional and other stresses that a vessel is subject to. For the slab work it will be found necessary to have at least a covering of 1¼ in. of concrete over all the bars, floors, frames and keelsons, and where heavy bars are used it is advisable to have a covering of not less than 1 in. of concrete, and even 1½ in. may be necessary. The deck may have a granite finish composed of ¼ in. washed granite and cement gauged 2½ to 1, laid at the same time as the under concrete, and sprinkled with fine carborundum before the casting is finished. The latest vessels being constructed by the author are having a chequer pattern cast in the finishing coat. For a 300-ton vessel a 3-in. shell or slabwork will be found sufficient, for a 500-tonner 3½ in., and for a 1,000-tonner 4 in. It will be noticed that in Fig. 9 it is proposed to fill a fillet of reinforced concrete under the wooden fender; this fillet could be arranged locally, say, 10 ft. apart, or continuously all round the vessel in way of the fender, which would enable the construction of an external side stringer to be formed, the inside stringer being consequently reduced. The advantage of the fillet is that the stress on the concrete due to the heavy falling of the ship and fender on to a pile, dolphin or dock wall is avoided. The section and longitudinal elevation of the 500-ton auxiliary coaster introduce several new features. The vessel having a length between perpendiculars of 155 ft., breadth 29 ft. 6 in., and a depth moulded of 13 ft. 3 in., is designed on the longitudinal principle, the frames being spaced 8 ft. apart. The hold ceiling would be fitted transversely in a vessel of this type, the frames and keelsons being hollowed to reduce weight and the inside curvature of the shell slabs or panels facilitating the use of light steel shuttering which is easily and quickly removed. Another method of reducing the weight is as shown in Fig. F, page 411.

Structural Details of Hull, Steelwork and Fittings.—The stern frame requires special consideration and design to ensure proper attachment to the concrete, especially where a stern tube is fitted. Fig. 2, page 367 *ante*, illustrates the author's patent stern frame, the construction in several pieces being really a war measure and designed to reduce the amount of forged work to a minimum. It will be noticed that the reinforced rods are well connected to the plates and angles. At present it is hardly worth while to make the rudders of concrete, although this is quite possible for large ships; the same remarks apply to masts. A method that may be adopted for attaching fenders or fender angles, bollards and holding-down bolts, is to cast in the concrete a tube with a flattened end that is screwed internally to take an ordinary or a cheese-headed bolt, although many fittings, such as stanchion sockets, small bollards,

mooring pipes, hatch cleats can be constructed with bulb or splayed ends, so that they can be cast in position, and consequently bolts or other attachments dispensed with. If this method is adopted, it would be as well to use malleable cast or wrought-iron fittings, to avoid breakage, if possible. Bulkhead connections, hawse and mooring pipes, wash port doors, scuppers and deck pumps are placed in position before the casting of the concrete takes place, and therefore cost practically nothing to fit. Shroud plates can be held down by bolts, although plates immersed in concrete and attached to the reinforced bars would no doubt be better. Deck-houses of wood will no doubt be more satisfactory in the early stages, although later these might be made of concrete.

Shuttering.—The generally recognised method of construction is to cast the concrete in moulds, these moulds being known as "shuttering," "centering," "frame work," "false work," "form work," "moulds," &c. At present the shuttering used is of wood, but in time, as standardisation proceeds, other materials will no doubt be adopted. Planed, tongued and grooved boards are desirable to obtain a neat fair surface of finish of the concrete work. Some builders of reinforced concrete ships have used plain boards, without the tongues or grooves, with the result that the concrete has pushed out the boards in places and left the surface uneven through insufficient supports being provided. For a large number of vessels of the same type it would

Fig. A. CURVE OF COMPARISON OF WEIGHTS.

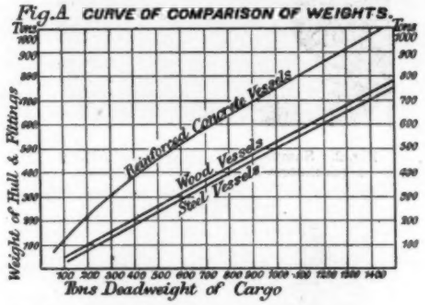
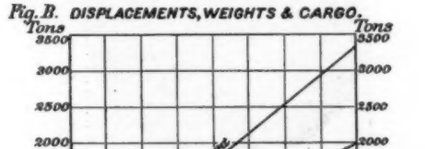


Fig. B. DISPLACEMENTS, WEIGHTS & CARGO.



probably be more economical, even at the present time, to use cast-iron shuttering. Pressed-steel shuttering would have the advantage of lightness, portability and durability, although it might be difficult now to get the authorities to sanction the use of steel for this purpose. Then, again, there is a possibility of reinforced concrete shuttering being used, especially for the flat bottom work, and for portions of the vessel where the heavier moulds can be handled with comparative ease. In designing the shuttering the pressure of the wet concrete should be calculated as that of a liquid of its own weight for the height that can be filled in before it is set. Camber of $\frac{1}{\text{360}}$ of the span of beam should be allowed for horizontal work, a careful examination being made frequently to see that the shuttering is not out of place before the concrete sets. The shuttering should be well wetted to close up the pores before the concrete is cast; some prefer to coat the wood with whitewash or a thin coat of paraffin wax, as it adds to the life of the timber and leaves the concrete clean when the centering is "struck." Striking of the shuttering should not take place before the concrete has set thoroughly hard, the bottom strutting being left for at least three weeks, excluding time of frosty weather.

Shipbuilding.—The best situation for building concrete vessels is the part of the country where the climate is warm and damp, and the ideal site is where the ground and foreshore are very hard and firm, in order that construction can be made without piling or expensive preparation, and where launching can take place with simple slipways. It is well to remember that there are very few shipbuilding sites that are suitable for building reinforced concrete vessels that do not require piling or other expensive methods of constructing the building berths to ensure freedom from damage during construction and launching, or require concrete slipways or reinforced concrete "rafts." To prevent concrete vessels getting out of shape when being built, and to launch without fracture, exceptional care is required. Side launching would appear to be preferable to the more usual "end-on" launching. The cost of constructing the water end or wharf for side launching will be almost as great as the cost of the "building ways." It is therefore advisable to provide for three or four building ways for each launching way, the declivity of the latter being 1½ in. per foot, but of the former somewhat less. It is very advisable to have the building slipways properly covered over to keep off the rain, and a complete building with sides would be an advantage, especially in an exposed position, as it would keep away the frost and cold. A ¾-yard power-driven concrete mixer should be used for vessels up to, say, 500 tons displacement, and a larger one, or two of the same size, for larger vessels. This mixer should be arranged close up to its work, and a suitable arrangement provided for taking away the mixed concrete from underneath by light railways, trucks, and tip wagons, as during casting a fresh charge should be mixed about every 3 minutes. Water must be laid on to the mixer. Cement storage bins should be arranged in a dry shed, the bottoms being well above the concrete floor of the building and the sides and backs of the bins clear from the side of the building so as to ensure the cement being kept absolutely dry until it is used. The sand and aggregate should be stored in the vicinity of cement storage bins. The rods for reinforcement should be ordered to the exact length to avoid scrap and waste.

Construction.—The workmanship must be of the very best, and superior to that of any concrete work on land, and the concrete kept free from frost and rain; work

Fig. C. CURVE OF CAPACITY.

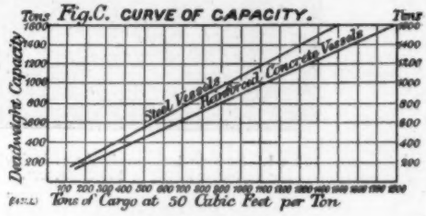
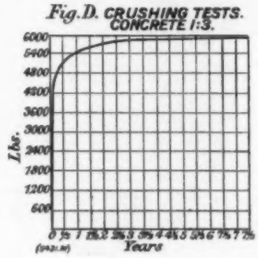


Fig. D. CRUSHING TESTS. CONCRETE 1:3.



should not be carried on when the temperature is below 35 deg. F. The $\frac{5}{16}$-in. and ¼-in. rods, as well as the larger ones, should be purchased in straight lengths and bundles; sometimes they are purchased in rolls, and then require to be straightened with a hand machine. If they are badly bent they should be warmed and straightened, and if bending is required it should be done cold. It does not matter if the rods are rusty in appearance, but they must be free from paint, grease, loose rust, dirt or other foreign matter. The shuttering and rods being in position, small distance blocks of concrete should be placed as required. For frames, beams, pillars, &c., it is advisable to have a block with one long channel instead of a small groove for each bar, so that any diameter of round bar can be used. All the blocks should have holes cast, so that wires can be used to hold them in position. It is necessary to mix the concrete thoroughly by machinery in quantities that can be immediately used, and to use it as quickly as possible after being mixed, as cement commences to set immediately it is mixed with water; under no circumstances should a concrete which has once been allowed to set be mixed again for use. Each section, if possible, should be completed in one operation. In mixing, clear fresh water should be used. Some claim that the correct consistency of the concrete is that it should be in a "mushy" state, i.e., when tipped out of a bucket it should not flow or run, but can be easily "tamped" with a tamping tool; others, that if the double shuttering is finished for a height of 5 ft. at a time, the concrete should be in a very liquid state and not tamped, the shuttering being vibrated or agitated instead. This latter method of casting 5 ft. at a time is not desirable for ship construction. The thickness of loose concrete that is to be tamped should not exceed 4 in. to 5 in. If contraction cracks or defects appear, the concrete should be cut out and the remaining surface thoroughly wetted and made good with cement mortar, i.e., sand and cement gauged 1 to 1.

When a section is stopped either for a meal hour or for the day, the surface should be made rough by the tamping tool or other means, some preferring a longitudinal groove as well. Before continuing, the surface should be damped well and coated with ¼ in. of cement mortar to ensure good jointing. The efficiency of the work depends largely upon the careful casting, and if at all possible continuous work is to be preferred, to ensure homogeneity. In tamping the concrete, which must be done thoroughly to increase the impermeability to water, care must be taken not to displace the steel reinforcement. The tamping is also necessary to get good adhesion to the bars. To get a smooth surface, besides agitating the shuttering during casting, the surface of the concrete should be rubbed over with cement 1 to 1 to fill all the interstices and when dry smoothed down and polished with a carborundum block. Electric rotary concrete surfacers are also used; these machines will surface from 50 sq. ft. to 70 sq. ft. per hour, after all voids have been filled in.

Fig. E. EXPANSION AND CONTRACTION OF CONCRETE.

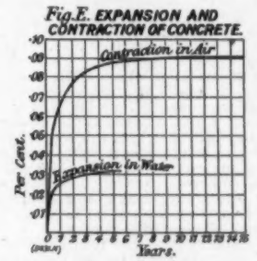
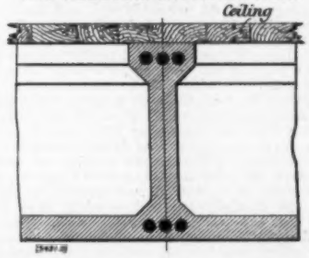


Fig. F. SECTION OF FRAME AND KEELSON. SECTIONAL VIEW.



The American "cement-gun" is sometimes used to apply to concrete. The mortar is placed in an upper chamber, the valve at the bottom of same being closed; when the chamber is full the top valve is closed and the bottom one opened, so that the concrete falls into the lower chamber. When the upper chamber is empty it is immediately refilled, so that the supply to the nozzle is continuous. Air is supplied from a compressor at 50 lb. per square inch for first coating or rough work, and 40 lb. for the finishing coat, the water to the lower chamber being supplied at 20 lb. higher than the air pressure. It is claimed that by this system shuttering is dispensed with and the construction of the vessel is much more rapid; the claims have not yet been proved for ship construction, and so far as can be seen the system is not likely to be adopted in this country, except for small boats.

Launching.—Designers and constructors may well feel nervous of the risk of launching vessels within a short time of completion. There are the three usual methods of launching: (*a*) Building in a dry dock and floating out, (*b*) launching end-on in the ordinary way, and (*c*) side launching. The ideal condition is to build a reinforced concrete vessel in a dry dock and float the vessel by filling the dock in the ordinary way; the interior of the hull can also be flooded with water to harden the concrete, and both operations carried out without putting an undue strain on the concrete structure. The objection to the general adoption of this method is that dry docks are rarely available for this purpose, as they can be more profitably used for repairing ships and because, if they were available even for a few months, the cost would be practically prohibitive. The second method is to launch end-on and stern first, as is usual in 97 per cent. of the steel vessels built. The stresses due to the vessel entering the water at a declivity and at a considerable speed are probably in excess of any ordinary stress that will be brought upon the vessel in a heavy sea, and to minimise risk of fracture a period of a month or two would be useful to allow hardening between the final casting and the launching. Nevertheless, it may be found more economical and convenient to adopt this method of launching if the building berth and foreshore is suitable and if numbers of vessels can be built at one time, so that the vessels after completion can be left standing for a month or two. If the building berth and foreshore for launching require considerable piling, it will probably be advantageous to adopt side launching, which may present slightly greater difficulties in the design and construction of the fixed launching ways, but will have the advantage of enabling the vessel to enter the water several weeks earlier. With the 500-ton deadweight auxiliary coaster referred to above, with a launching displacement of 425 tons, eight fixed ways will probably be sufficient, the declivity being 1½ in. to the foot. If the ground is good, it should take a load of 2 tons per square foot. The Beton I referred to above, was launched with the keel uppermost, necessitating sufficient airtight chambers being fitted to give the necessary buoyancy when flooded and during the process of turning over.

In the case of a Thames "swim" barge now being constructed by the author, which has a length of 77 ft. by 21 ft. 6 in., and a depth of 7 ft. 3 in., with a deadweight capacity of 130 tons, it has been calculated that (*a*) it can be supported light by one transverse support across the centre of the bottom, and (*b*) that when loaded it can rest on a "camp-shed" high and dry, with one-third the length overhung, or (*c*) still under loaded condition be

left across a small river or canal, with each end resting on a bank and one-third of the length in the centre entirely unsupported. The seagoing tests, even in a heavy sea, should not be difficult to carry out, but the launching, bumping into other vessels, quay walls, &c., will no doubt be more severe, though it has been stated above that good local strength is provided for. After launching, careful observation should be made to see whether the hull is watertight, and if it is found to make little water, flooding internally will help to fill up the pores and interstices and also harden the concrete.

Tests of Concrete Vessels.—There is as yet little available information regarding actual experience from tests of concrete vessels, and the following results, taken from Mr. H. Alfsen's recent lecture to the Polytechnic Association in Christiania, are therefore of interest. The vessel tested was the Beton I, already referred to. Concrete blocks were used for the loading, and were so disposed as to give the load per foot-run amidships twice that at the ends, the full load amounting to 182 tons. A depression of 10 mm. fore and aft was observed, 3 mm. being due to the loading of the deck, leaving 7 mm., which compared admirably with the calculated figure 6.5 mm., when one considers the uncertainty in fixing the modulus of elasticity, which was taken as 890 tons per square inch. The bottom beam showed a total elevation of 2 mm., while the ribs showed 6 mm. bending inwards, and 5 mm. bending outwards, when the deck was loaded, which are insignificant deformations. The calculated stresses corresponding to the loading are as follow: Pressure on deck, 427 lb. per square inch; shearing in the skin, 120 lb. per square inch; tension in bottom, 10,000 lb. per square inch. The surface was scrutinised under a magnifying glass at the point of maximum shear and at all accessible places, and no sign of cracking or failure was anywhere observed. When the loading was removed, all the strains proved to be elastic except 1 mm. depression fore and aft remaining. Probably time will show that this was only due to inertia in the material, and that no permanent set was produced. Some moist spots appeared in the sides while the loading proceeded, and were carefully observed and found to disappear before the loading was completed, showing that further setting took place in water wherever the concrete was left somewhat porous.

Cost of Construction.—The prime cost of the finished reinforced concrete work for an ordinary vessel with ship-shaped lines at the present time should average 6*l.* 15*s.* per ton, made up with the double shuttering at 18*s.* per square yard for timber and 6*s.* 6*d.* for labour—the concrete at 1*s.* 8*d.* per cubic foot, and the round steel bars from 16*l.* 10*s.* per ton for the large diameter to 22*l.* 10*s.* per ton for the small diameters. Vessels with straight lines will cost less, and probably a saving of 1*l.* to 1*l.* 5*s.* per ton will be made, the usual establishment charges and profit being added. These figures are based on a 300-ton deadweight coaster, and for the first vessel only. Larger vessels would, of course, show a reduction. Assuming that the shuttering will last for five vessels of the same design, the cost of the wood could be divided over that number, but would require an addition of 10 per cent. of wood in each case to cover depreciation and damage. If the wood were coated, as mentioned above, the straight shuttering might last for eight vessels and the curved for six vessels. The cost of removal and re-erection for the second and subsequent vessels might be taken at, say, 9*s.* per square yard for double shuttering on each occasion. The cost of fenders, woodwork generally, fittings and equipment will be the same as for a steel or wooden vessel of the same size, but owing to the larger dimensions, will be about 8 per cent. greater for a vessel of the same deadweight. A considerable reduction is obtainable in the labour because anglesmiths, platers and riveters are practically dispensed with. Taking the hull complete and comparing with steel and wood construction, even if the steel is obtainable at 11*l.* 15*s.* per ton, concrete vessels of the same deadweight should, if standardised, be constructed at 20 per cent. less cost than a steel vessel, and 10 per cent. less cost than a wooden vessel. The machinery for propulsion will, of course, cost more because of the extra displacement.

With regard to the time for construction after, say, three building berths have been prepared; with ample labour available, and after the first vessel has been cast, the one set of shuttering, so long as it lasts, should enable a barge of 130 tons deadweight to be completed and launched every ten weeks, a 300-ton deadweight coaster every 16 weeks, and a 1,000-ton deadweight coaster every 20 weeks.

Insurance.—Insurance may be a little expensive until these vessels prove their reliability, and until the classification societies are able to give them a full class.

Reinforced concrete ships will no doubt in time prove their reliability and safety, their capability of making ocean voyages, and of withstanding shocks due to seagoing conditions, and show that damage by collision will not be more serious than in steel vessels. If so, they have a future for at least some years to come, and for river and harbour work for a much longer period in spite of the great disadvantage of the extra weight that will always be with them. Generally, the immediate future for vessels in reinforced concrete seems substantial and most hopeful, and as a result of the many experiments and constructions now being made throughout the world, particularly in the British Isles, great improvements will be made as experience is gained; the excessive weight will be reduced, and the utility and earning power of the vessels increased. The limitations imposed on this paper prevent a description of the features of special types of reinforced concrete vessels that are urgently wanted in this country, such as seagoing and river tugs, swim and river barges, channel and coastwise vessels, &c., and the problems that have to be dealt with in their design and construction. Perhaps an opportunity will be given to discuss these vessels and the various specialised problems which they present in a later paper.

ON THE ANNEALING OF ALUMINIUM.*

By ROBERT J. ANDERSON, B.S., Met.E. (Cleveland, Ohio, U.S.A.).

DURING the course of some recent tests on the annealing of cold-rolled aluminium sheet, an examination was made of certain samples of commercial aluminium sheet (16-gauge) which were sent to the writer's laboratory. A brief description of the work performed is here presented, mainly for the reason that very few accounts on the metallography of aluminium have appeared in scientific publications. Certain samples of supposed aluminium sheet were received with a request for complete—so far as possible—chemical and metallographic tests. Casual examination indicated that the metal submitted was aluminium, and the chemical analyses confirmed this. The samples showed the percentages of elements given in Table I.

TABLE I.—*Chemical Analyses of Samples.*
Aluminium by Difference.

Marked Sample.	Percentages of Elements.				
	Copper.	Iron.	Silicon.	Manganese.	Aluminium.
1	trace	0.69	0.25	trace	99.06
2	trace	0.90	0.06	trace	99.04
3	trace	0.87	0.22	trace	98.91
4	trace	0.85	0.23	trace	98.92
5	trace	0.74	0.55	trace	98.71

The chemical analyses are interesting because of the variance from the usual run of American metal, on which the average chemical analysis is:—

	Per Cent.
Copper	0·11
Iron	0·32
Silicon	0·37
Manganese	trace
Aluminium	99·20

The iron in the metal examined is rather high, while copper is present only in traces, and the metal is evidently of an inferior grade than best American aluminium. The hardness of the samples as received was taken with the Shore scleroscope, with the results given in Table II.

(Reduced 50% in reproduction.)

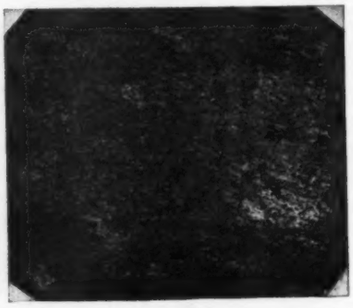


Fig. 1. Sample 2, as received; etched with Hydrofluoric Acid; × 100 diameters.

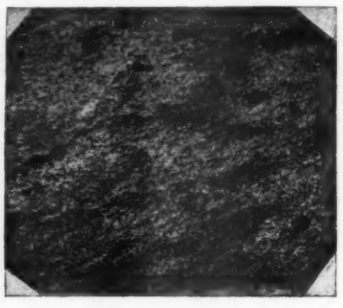


Fig. 2. Sample 3, as received; etched with Hydrofluoric Acid; × 100 diameters.

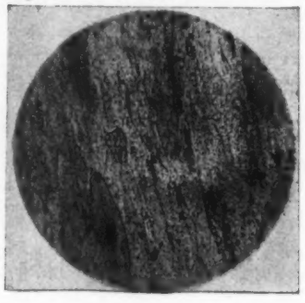


Fig. 3. Sample 5, as received; etched with Hydrofluoric Acid; × 215 diameters.

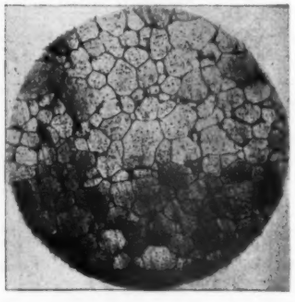


Fig. 4. Sample 1 after annealing; etched with Hydrofluoric Acid; × 50 diameters; grain size 50 per sq. mm.

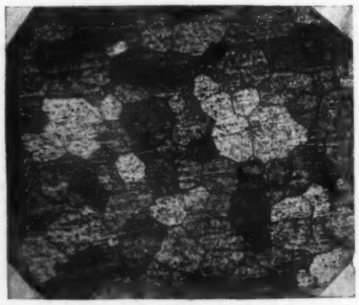


Fig. 5. Sample 5 after annealing; etched with Hydrofluoric Acid; × 100 diameters; grain size 150 per sq. mm.

TABLE II.—*Shore Scleroscope Hardness of Samples.*

Sample Marked.	Hardness Number.
1	8
2	6
3	8
4	7
5	9

The Shore hardness values indicate that none of the samples was in the annealed condition; they had been hardened either by cold work or strain, or else had been partially annealed with a consequent fall in the Shore values. These hardness numbers do not indicate severely worked aluminium; a commercial 16-gauge sheet (with over 99 per cent. aluminium, and impurities normal) would have a Shore value of 13 to 15 when in the severely-worked condition, and a Shore value of 4 to 5 in the annealed state.

Microscopy.—Microsections were secured, polished and etched, and examined under moderate powers. The results of the microscopic examination are summarised in brief in Table III.

TABLE III.—*Microscopy of Samples.*

Sample Marked.	Remarks.
1 ...	Amorphous; indicating a hard-worked sheet.
2 ...	Grain boundaries visible, but greatly distorted.
3 ...	Amorphous; similar to 1.
4 ...	Amorphous; similar to 1.
5 ...	Crystalline grains elongated in the direction of work.

A consideration of the chemical analyses, Shore values, and microscopy is interesting. Sample 1 appeared to consist of amorphous material, but the scleroscope hardness was only 8, so that this sample had possibly been cold-rolled and then partially annealed. Aluminium may be softened by annealing so that its Shore value is around 4 to 5, and still present an amorphous appearance under the microscope. Samples 2, 3 and 4 might be judged in the same way; the high iron would make for greater hardness than would be otherwise expected.

* Paper read before the Institute of Metals on March 18.

Sample 5 had a higher Shore value than any of the other samples, which would appear contradictory in the face of the chemical and microscopic data.

Results of Annealing.—In order to convert the amorphous or partially amorphous metal, in certain of the samples, into the crystalline form, a few annealings were made. Thus sample 1 was heated to 540 deg. C. for 15 minutes, and then cooled to room temperature with the furnace—the cooling taking place over night, and the annealing being performed in a small electric furnace of the resistance type. The structure of sample 1 prior to annealing was similar to that shown in Fig. 1, while after annealing it was like the structure in photomicrograph Fig. 4. In the same way, the elongated grains in Fig. 3, which is a photomicrograph of sample 5, were equiaxed by a similar annealing; the structure of sample 5 after annealing is shown in Fig. 5. This behaviour is, of course, typical of metal in general, and the laws for annealing aluminium are, in their general aspects, the same as for other metals. Aluminium however, exhibits a certain sluggishness toward recrystallisation—as has been previously observed in the literature of the subject—and it requires relatively higher temperatures, or longer times, or both, depending upon the amount of amorphous material present or the amount of deformation to bring about recrystallisation, than would be expected.

The effect of deformation on the recrystallisation of aluminium is instanced by a consideration of the grain size of samples 1 and 5 after annealing (see Figs. 4 and 5). The grain size of sample 1 is 57 grains per square millimetre, while that of sample 5 is 150 per square millimetres. The structure of sample 1 prior to annealing was like that in Fig. 1, obviously more deformed than Fig. 3, which was the structure of sample 5 prior to annealing. Both annealing treatments were identical, but the grain size of sample 1 is considerably larger than that of sample 5.

ELECTRIC POWER SUPPLY AND COAL CONSERVATION.

A DEBATE on the interim report of the Coal Conservation Sub-Committee on Electric Power Supply of Great Britain took place at the Engineers' Club, Manchester, on Tuesday, March 5. Mr. George Hughes presided. Mr. S. L. Pearce, chief electrical engineer of the Manchester Corporation, was the principal speaker. He said:—

"Few reports have ever been issued which have created such widespread interest as the one under consideration. It has had a very wide press indeed, and if I may judge from some of the comments which have been made, the report is supposed to herald the era of cheap electricity. Now the Coal Conservation Sub-Committee is not the only Committee that has been appointed to consider this very important question. I may refer to the National Electrical Power Supply Joint Committee for the members of the Incorporated Municipal Electrical Association and members of the Incorporated Association of Electric Power Companies. Also the Committee of the Institution of Engineers, and, coming nearer home, the Engineers' Committee of Lancashire and Cheshire. The report of the Coal Conservation Sub-Committee is styled "An interim report." There is another tribunal considering the question, viz., the committee appointed by the Board of Trade under the chairmanship of Sir Archibald Williamson. The report of that committee is likely to be issued at no distant date.

I want to say at the outset that, with the major portions of the committees' recommendations I am more or less in agreement, in so far as they contain suggestions bearing on engineering and technical questions.

We will take the first recommendation—which, in effect, is that the present system of over 600 districts, each having its own undertaking, should be superseded by a comprehensive system under which the country is divided into some 16 areas. I think few will contest the soundness of the underlying principle without committing themselves to an agreement with a particular number of 16, which is likely to be very substantially increased.

I now pass to the second and third recommendation, and I will take them together, as they both bear on the same subject, viz., the selection of sites for the new super-power stations. The committee suggests that sites should be chosen on important waterways. I quite agree. It is very desirable, exceptionally desirable, if you can obtain sites of that character, more especially so, if the coal facilities are equally good. It is, of course, well known that the North-East Coast possesses plenty of good sites on important waterways in close proximity to collieries, but this is not the case all over the country by any means. In Lancashire, I think it would be true to say that the converse is the case. I know of no inland sites in Lancashire which possess ample water facilities for super-power stations of, say, 100,000 kw. Remember what is required, is not a series of trickling streams, but a waterway with a minimum flow of 8,000,000 gallons to 10,000,000 gallons per hour, or its equivalent. So, we naturally ask this question: What is the alternative to these waterways? The answer is, cooling towers. I myself entirely dissent from a wholesale condemnation of cooling towers, as I hold that the transmission cost from a waterside site may more that counterbalance the extra working cost due to cooling towers. So I come to the conclusion that the whole of this report is too much coloured by North-East Coast experience, and North-East Coast facilities. I have made very elaborate calculations about the question of a Mersey-side site for Manchester, a site at which it would be possible to obtain ample river water for condensing purposes. I assume a super-power station. The load to be transmitted from that station was 100,000 kw., 0.8 power factor, 66 per cent. load factor, transmission voltage 150,000 volts, which is the highest voltage that has so far been used in the States. The annual charges on such a transmission line would be of the order of 100,000*l.* to 125,000*l.* per annum. That is the cost of the transmission line. Supposing we were to establish a station in Manchester and use cooling towers, it would result in an increased coal bill, because it is impossible with cooling towers to obtain a vacuum of more than 27 in. or 27½ in. at the outside, as against the figure of 29 in. or 29½ in. with a natural waterway and plenty of cold water. Therefore, I have assumed an increased coal consumption of 15 per cent. Then there are all the costs incidental to the towers. Summing up, I estimate that, the extra annual cost for cooling towers compared with a natural waterway are of the order of 70,000*l.* per annum. So that on the one hand, we have transmission costs of 100,000*l.* to 125,000*l.*, and on the other hand the figure of 70,000*l.*, clearly in that case it would not pay Manchester to go to the Mersey-side for current.

I would also like to examine for a minute or two, the question of transmission costs in relation to coal transport costs. There again taking the same data, viz., 100,000 kw. transmitted, voltage 150,000 watts, 0.8 power factor, 66 per cent. load factor, I have come to this conclusion, that it would only pay to establish power stations 30 miles away from the area of supply if you can get coal 5*s.* per ton cheaper. Facilities being the same in those two areas—that is to say, a station in your own area and a station 30 miles away. So the general conclusion I have come to as regards Manchester, still on the same basis, is, that it would not pay Manchester to have a power station at a distance exceeding 20 miles from the area of supply for the purpose of obviating the use of cooling towers, assuming there is no advantage to be gained in the cost of coal.

A second point is, that the above figure of 20 miles could be increased to the extent shown in the previous calculation, if cheaper coal and ample water were both available. Such sites do not exist in Lancashire.

The third point is this: It is of a general character that it is difficult always to establish a case in favour of transmitting electrical energy rather than railing coal. The superiority of electrical transmission only becomes apparent with very high load factors.

My chief ground for criticism of these two recommendations of the committee is that they appear to lay too much stress on the suitability of a site to enable them to obtain a low cost at the station bus-bars; that they have rather stressed that point because of the importance they have attached to the establishment of electro-chemical works alongside the station, and that they have shut out to too great an extent, the question of the cost of transmission. Insufficient stress is laid on the desirability of having a station site, well situated with regard to the load which it has to supply.

I now pass to the fourth recommendation, in which the committee advocate the preparation of plans for the construction immediately after the war of these large super-power plants. I think we ought to ask who is the competent authority to select the sites? Therefore, I hope that the Commissioners or whatever Government Tribunal may be appointed, may be set up as soon as possible so that there may be some co-ordination given to this national policy and the final approval of the sites that may be selected should rest with the Commissioners. I say that advisedly, because, at the present, it seems that there is a great tendency on the part of various authorities, both company and municipals, to start pegging out claims in advance.

The fourth recommendation in conjunction with Clause 47, contains this sweeping statement: "Existing generating plants are uneconomical and ought to be scrapped." Whilst it is obvious that very many plants are out of date—the majority, if you like—I do dissent from the policy which seems to be advocated in this report, of wholesale scrapping. I think we shall attain to a truly national policy by evolution rather than revolution. So far as Lancashire is concerned, the conclusion I have come to is that some existing stations can be usefully extended with large plants and, therefore, these extensions together with the erection of the super-power stations, may very well go forward together.

I fully agree with the recommendation contained in this report that any inter-connecting scheme to be effective must be coupled with unity of control. It is estimated that in Lancashire there is a million or a million and a quarter of coal consuming horse-power in the 35 undertakings which are referred to in the Lancashire and Cheshire reports. The maximum demand on these last year was 175,000 kw., equivalent to about 600,000 h.p. installed on consumers' premises, so that the margin between the 600,000 and the one and a quarter millions will afford plenty of scope for power extensions.

I now turn to the fifth recommendation, viz., that by-product plant should be combined with power plant. I think the sub-committee here show a very commendable degree of caution which is somewhat lacking in other parts of the report. They are evidently of opinion that the question as to whether electricity or electric power can be obtained more cheaply if the coal used for steam-raising is first subjected to processes of carbonisation, and gasification has not yet been satisfactorily answered.

The next and sixth recommendation of the committee is in connection with waste heat stations. There, I think, there will be practical unanimity with their proposal. Waste heat stations have proved to be very advantageous on the North-East Coast, and in the majority of cases I believe they have incidentally involved the use of cooling towers.

Now I come to what is a very contentious point; *i.e.*, the seventh recommendation in the committees' report, in sub-section 7 of Clause 48—the question of stopping extensions to all existing stations. That, I think, is too general a statement to be adopted on its face value; but, at any rate, it will give a text for dealing with the famous Table 5 of this report and Clause 27—a table which has been very severely criticised, and which, I venture to say, should never have been found within the pages of this report. It purports to be a comparison between the price of energy on the North-East Coast and energy in Lancashire. The comparison is very misleading and grossly unfair.

To the casual reader considering Clauses 26 and 27 of Mr. Merts's report, the latter is certainly capable of bearing the interpretation that the reason for the excellent results on the North-East Coast as compared with Lancashire is that it is company control in the one case and municipal control in the other. The first thing to do, of course, when drawing comparisons, is to see that you compare like with like. This table does not do so. If you want to get a true comparison, you should compare power units with power units; high-tension units with high-tension units. This report makes the great mistake that in comparing the price per unit, it is not by any means taking the same kind of unit in each case. There is a broad distinction that can be drawn. The North-East Coast output is mainly a bulk supply—a power supply. Lighting is a very small portion of their business. In Lancashire that is not the case. Taking the municipalities as a whole, they deal with a mixed business. The bigger proportion is power, but there is a big lighting load and a big tramway load. In the North-East Coast, it is not, as has been pointed out by Mr. Tracey in the municipal journal, a finished article; something has to be done to the energy after it is delivered in the form of bulk supply. In Lancashire, for the most part it is the finished article which is delivered, either in the form of high-tension or more often low-tension energy at the consumer's terminals. Therefore, to the North-East Coast prices you must add figures that will cover the cost of transforming and distributing the high-tension energy which is delivered in bulk. Take one case only. Take the case of Tynemouth. The figures with regard to this have been given by Mr. Tracey, and I have no reason to suppose that they are inaccurate. The bulk supply price to Tynemouth from the Newcastle Company is not 0.5*d.*, it is 0.64*d.* These are high-tension units. Now, after transforming and adding distribution charges, the Tynemouth prices are as follow:—

	Per Unit.
For private lighting	1.05*d.*
For public lighting	1.7*d.*
For tramway supply	1.27*d.*

If you will be good enough to compare these prices with Lancashire, you will see they are very similar, although Tynemouth has the advantage of purchasing its bulk supply from the Newcastle Company at what is supposed to be an extraordinarily low rate.

By way of further argument, I would call your attention to a table which I have put in evidence before the Board of Trade, dealing with a number of towns. It is an average selection of large and medium-sized towns of Lancashire and Cheshire, and I deal first of all with the average price per unit sold for industrial power purposes. It is the power delivered at the consumer's terminals in low-tension in nearly every case. The prices vary from 0.47*d.* to 0.68*d.* I would also draw your attention to the percentage of industrial power units sold in these undertakings, which varies from 53 per cent. to 90 per cent., the Manchester figures being 75 per cent.

I also want to take this comparison a stage further and to deal with the question of the output per head of population, on which, so much stress is laid in Clause 27 of the Mertz Report. There the statement is made that on the North-East Coast they sell 3½ times as much energy per head of population as we do in Lancashire. They do not give any definite figures. If you will refer to Mr. Sloan's paper, he gives the industrial population of the North-East Coast, and dividing this figure into the output from the Newcastle Company, for that particular year, the resulting figure is, I think, 184 units per head of population. The comparable figure for Lancashire is 164, while that is the figure for Lancashire, the figure for Bury is 233, for Manchester 241 and for Stalybridge 265. From this standpoint alone, I am not able to appreciate where "the freedom of range and keenness which are distinctive of private enterprise" comes in. Bear this in mind, that any comparison made between the North-East Coast and Lancashire must be to the disadvantage of Lancashire, in view of its densely populated character. Another point, and this is a very vital point, viz., the question of finance. This comparison pre-supposes that the methods of finance of the company and municipality are exactly the same. Do the companies on the North-East Coast set aside out of profit the same amounts for reserve and depreciation? They are very different indeed. Let me again take the case of Manchester and compare it with the North-East Coast. In each case, the capital outlay is about the same, about 3,250,000*l.*; but, whilst for depreciation purposes, they put aside 30,000*l.*, equal to about 1.14 per cent. on the capital outlay, Manchester puts aside 160,000*l.*, which is equal to 5 per cent. This deficiency alone makes a difference on the Manchester output of 0.19*d.* per unit, so it is absurd talking of Table 5 being a true comparison. I make the broad statement that, generally speaking, local authorities both produce and sell more cheaply than companies.

Now I come to one of the last recommendations, viz., the advocacy of setting up electric commissions with certain definite powers. So far as I can gather, that is the one point upon which there seems to be more or less agreement.

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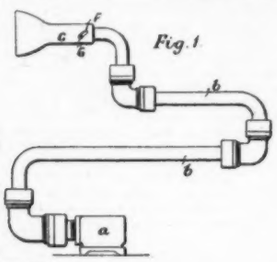
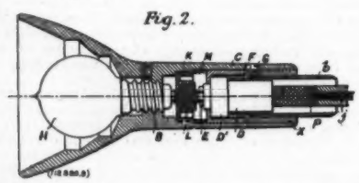
ELECTRICAL APPARATUS.

112,320. Sir W. G. Armstrong, Whitworth and Co., Limited, and A. S. Cheetham, Newcastle-upon-Tyne. Electric Lighting. (7 *Figs.*) January 8, 1917.—The object of the invention is to provide an improved lamp holder reflector and switch, especially applicable for local illumination with a light which is capable of being moved, although the conductor and terminals are enclosed within rigid tubes. In Fig. 1, *a* is a fixed base and *b* are tubes capable of turning movements with respect to each other, preferably by spigot and socket connections, by which the tubes are capable of rotation while maintaining electrical continuity between all parts. Referring to Fig. 2, the lamp holder consists of a tube or shank C and a reflector. H is the lamp screwing into the screw-threaded aperture B, F is the bayonet slot, X is a ferrule screwing on to the last tube

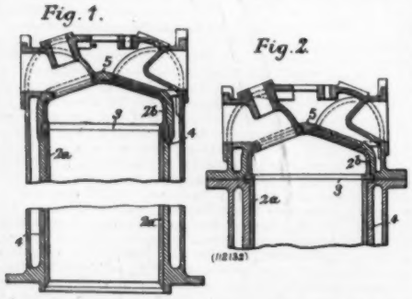




of the series, and G is a pin on the ferrule which engages the slot F. K is an insulating disc, L a spring buffer contact interposed between the contact on the lamp H and the conductor terminal E. M is a spring for keeping the lamp holder in either of its extreme positions. J is a flexible conductor, P its metal braiding, and D a sheath fitting into the last tube of the series and carrying, but insulated from, the terminal E. The sheath is provided with an external collar D1, which fits into a corresponding internal groove formed by the parts making up the ferrule X; the sheath is therefore free to rotate but cannot move laterally in the ferrule. By rotating the shank C anti-clockwise the spring M will force the lamp holder from the position shown to a position in which the pin G is at the other extreme position of the slot F, thus breaking the lamp circuit. (*Accepted January* 16, 1918.)

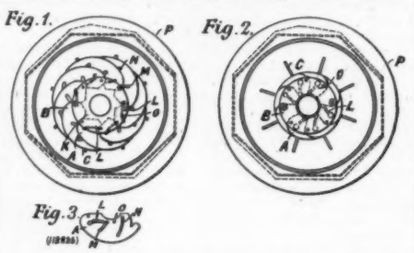
GAS ENGINES, PRODUCERS, HOLDERS, &c.

112,132. S. S. Guy, Wolverhampton. Cylinders. (2 *Figs.*) April 12, 1916.—This invention has reference to the cylinders of internal-combustion engines of the kind made of aluminium and cast, with or without a water jacket, about a liner. The liner is made in two parts, 2*a*, 2*b*, the line of division 3 forming for convenience the termination of the inner end of the working bore of the cylinder 4. The parts of the liner may



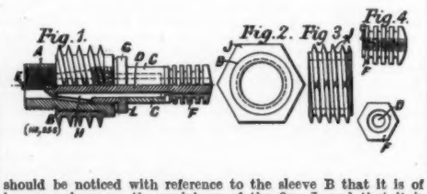
be either permanently united by welding, or detachably connected by being screwed together as shown in Fig. 1, or by butting, as represented in Fig 2, the latter arrangement lending itself for use where the combustion head 5 itself is also detachable. The lower part 2*a* of the liner is cylindrical, and forms the working surface for the piston. The upper part 2*b* may obviously vary in shape and size according to the design of combustion head to which it is applied. The cylinder 4 and combustion head may either be cast around the liner as represented in Fig. 1 or built up about it as shown in Fig. 2, or deposited on the liner by an electrolytic process, or again the liner may, where the circumstances admit of it, as where the combustion chamber is of less diameter than the bore of the cylinder, be introduced or forced into the cylinder. (*Accepted January* 9, 1918.)

112,226. Mann Egerton and Co., Limited, and A. B. Drummond, Norwich. Internal Combustion Engine Radiators. (5 *Figs.*) May 4, 1917.—This invention relates to means for closing the opening for admission of air to internal combustion engine radiators so that the amount of cooling surface exposed to the air current can be varied. P represents the outline of the fuselage of an aeroplane having a radiator fixed at its front end. A detachable plate K with an open centre is fitted on the front of this radiator, a framework C is fitted behind the plate K so as to safeguard the radiator, and between these two elements a series of rotatable shutter plates A, A, are arranged on pivots so that they can either be closed almost within the plate K or opened out to the full extent of the frame C. The plates are shaped with their outer edge of a semi-circular



character, and each plate is provided with two slots M, N, where it embraces the pivot of a succeeding plate; in addition, each plate is provided with an upstanding pin O, by which it is connected to the succeeding plate by means of a slot L, so disposed in relation to the turning movement of the plates between their closed and open position that the movement of the pin in the slot L transmits the movement of one plate so as to cause similar movement of the next plate. The opening and closing movements of the plates are accomplished by means of two master plates B, B, arranged one on each side of the radiator, and these need not be provided with the slots L as they are turned directly by spindles which pass through to the back of the radiator, where they are connected to arms provided with turning means. (*Accepted January* 9, 1918.)

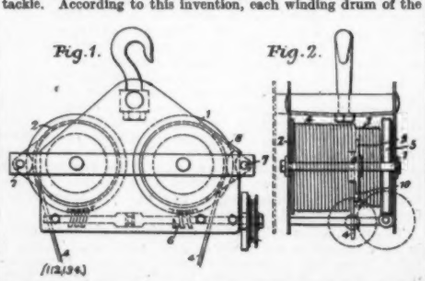
112,256. W. H. Pease, Mapperley. Sparking Plugs. (4 *Figs.*) October 15, 1917.—This invention is concerned with the type of sparking plug having heat radiating fins around its body, or electrode, or both. A is the plug body, and B is a cooling fin sleeve threaded on to the body A. E is the electrode tightly threaded at one end into the centre-pin D, which carries at its opposite end a cooling nut F, grooved for the attachment of the electrical conductor so as to form hexagon-shaped fins, and by which nut a distance bush C is secured; a nut G and internal bush H, of which the latter may advantageously be of china, for insulating purposes, is interposed in the ordinary way to form (together with bush C) the insulation part of the plug. The inner part H is attached to the plug body by screwing the nut G into the plug body A, which has its front part threaded for attachment to the cylinder in which it is to operate. It



should be noticed with reference to the sleeve B that it is of hexagon shape on the periphery of the fins J, and that it is connected to the body A of the plug by a fine thread meshing with a similar thread on the body, and that it is locked thereon by tightly screwing B against the flange L of the body. Further, in order to render it of a form for quick and inexpensive manufacture, the fins J are formed as a continuous spiral or helical rib which can be cut by a tool with a continuous travel from one end to the other. By thus having the cooling fins in a very intimate connection but separate on the body of the plug and of a special heat-resisting metal, such as muntz metal, and the cooling nut on the end of the centre pin of aluminium, a very advantageous arrangement is obtained for resisting or radiating the heat in a high-speed engine, the plug being kept also of light weight. (*Accepted January* 9, 1918.)

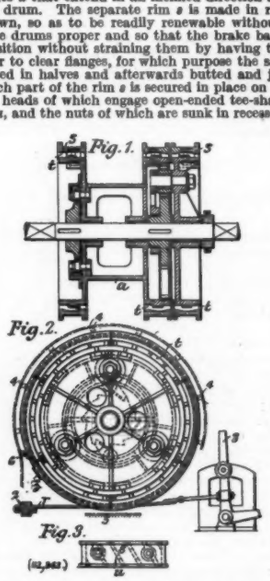
LIFTING AND HAULING APPLIANCES.

112,134. G. E. Parkes, J. C. W. Peel, and W. H. Chapman, Sheffield. Lifting and Hauling Tackle. (5 *Figs.*) September 23, 1916.—This invention relates to lifting and hauling tackle. According to this invention, each winding drum of the



block is provided with a guide having two curved edges, one edge fitting in the groove next to the last lap of the rope or chain which leaves the drum, whilst the other is located in the same groove as the last part of the rope or chain on the drum. The pulley block is provided with drums 1 and 2, which have spiral grooves 3 formed on their peripheries to accommodate a rope 4. Each drum is provided with a worm wheel 5, which is driven by a worm 6, one being right-hand and the other left-hand. Extending lengthwise of the drums are guide rods 7, parallel to the drums axis and at or about the same horizontal level mounted on these guide rods are guides 8, which are capable of sliding backwards and forwards along the guide bars in response to the movement of the rope. One portion 9 of the guides fits within the groove of the drum next to the last lap of rope or chain which leaves the drum. Portions 10 of the guides, which are disposed considerably below the level of the guide rods 7, fit within the same part of the grooves as the last part of the rope on the drum, but extend for only a short distance around the drums. The portions 9 of the guides keep the last part of the rope on the drums in their proper grooves, or if by any means they get into the wrong grooves and unwinding commences, the flat sides of the guides push them back at once into their proper grooves. In the same manner portions 10 keep the rope in its proper groove, or if by any means it gets into wrong grooves, and winding commences, these portions push the rope into the proper grooves. By means of this device the rope is always immediately pushed back into its proper groove, or grooves, by one or other of the portions 9 or 10, if it should happen to get out of the same. (*Accepted January* 9, 1918.)

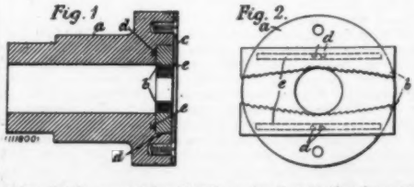
112,242. G. T. Macfarlane, Pinner. Winches. (3 *Figs.*) January 22, 1917.—This invention relates to winches. The barrel *a* is driven in a hoisting direction through epicyclic gear. The brake bands *r* are all fitted with wearing blocks preferably shod with Ferodo, and to prevent undue heating the brake rim *s* of each drum is made separate from the drum proper, and between it and the drum is an annular space or passage *t* in which are vanes or blades *u* that extend in an inclined direction across the width of the drum. The separate rim *s* is made in removable parts, as shown, so as to be readily renewable without having to remove the drums proper and so that the brake bands *r* can be put in position without straining them by having to expand them in order to clear flanges, for which purpose the said bands are constructed in halves and afterwards butted and jointed at the top. Each part of the rim *s* is secured in place on the drum by bolts, the heads of which engage open-ended tee-shaped slots in the drum *a*, and the nuts of which are sunk in recesses formed



therefor in the parts of the rim *s*. Each brake band *r* comprises metal strips connected together at *z*, as regard the band *r* shown in Fig. 2, one or more of the strips extending from the point of connection around the drum to the point of anchorage 2, and the other, or others, in like manner extending around the drum to the operating device 3. To ensure uniform gripping and release of the band *r*, fixed stops 4 are provided at intervals about the diameter of the drum, as indicated in dot-and-dash lines in Fig. 2. These stops successively limit the outward expansion of the band *r*, as the brake is released or moved into its off position and consequently causes such band to quickly and practically simultaneously clear the drum throughout its diameter. At the point where the band ends are led away from the drum to the point of anchorage and the operating mechanism, a stop or abutment 5 is also provided for the same purpose. 6, Fig. 2, indicates a spring of which there may be several that tend to pull the band away from the brake drum to facilitate quick release of the brake. (*Accepted January* 9, 1918.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

111,800. W. Mainwaring, Tipton. A Wrench. (2 *Figs.*) May 14, 1917.—This invention provides an improved wrench applicable more especially to the insertion and extraction of screwed studs and comprises the combination with a holder, of a pair of double wedges, each double wedge being formed in one piece with the smaller end of the wedges adjacent. *a* is a hollow cylindrical holder with a transverse slot cut at one end. The wedges *b* are arranged in this slot and held in position by a thin cover-plate *c*, having a hole at its centre in line with the interior of the holder. To prevent the wedges from falling out



of the slot in an endwise direction, pins *d*, projecting from one side of each wedge, engage a slot *e* in the holder, which is closed at its ends. Each wedge is flat along one edge and at the other edge is inclined from each end towards the centre, thus forming a double wedge having the small ends adjacent. The inclined operative edges are oppositely notched or serrated. In action, the tool is slipped over the stud, and during rotation the latter is firmly gripped by the wedges. The double wedges enable the tool to operate in either direction of rotation. (*Sealed.*)